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and Mines
Ontario

Aggregate Resources Inventory of
Northwest of Fort Frances
Northern Ontario

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Aggregate Resources Inventory
Paper 150

By Staff of the Engineering and Terrain Geology Section,
Ontario Geological Survey

1990

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ERRATA FOR ARIP 150

Aggregate Resources Inventory of Northwest of Fort Frances

The following errors have been detected in this report. These errors have been corrected and are printed in this folio.

1. Figures 14 and 15 were not printed correctly. The correct versions of these figures are included in this folio.

We apologize for any inconvenience this may cause the reader.

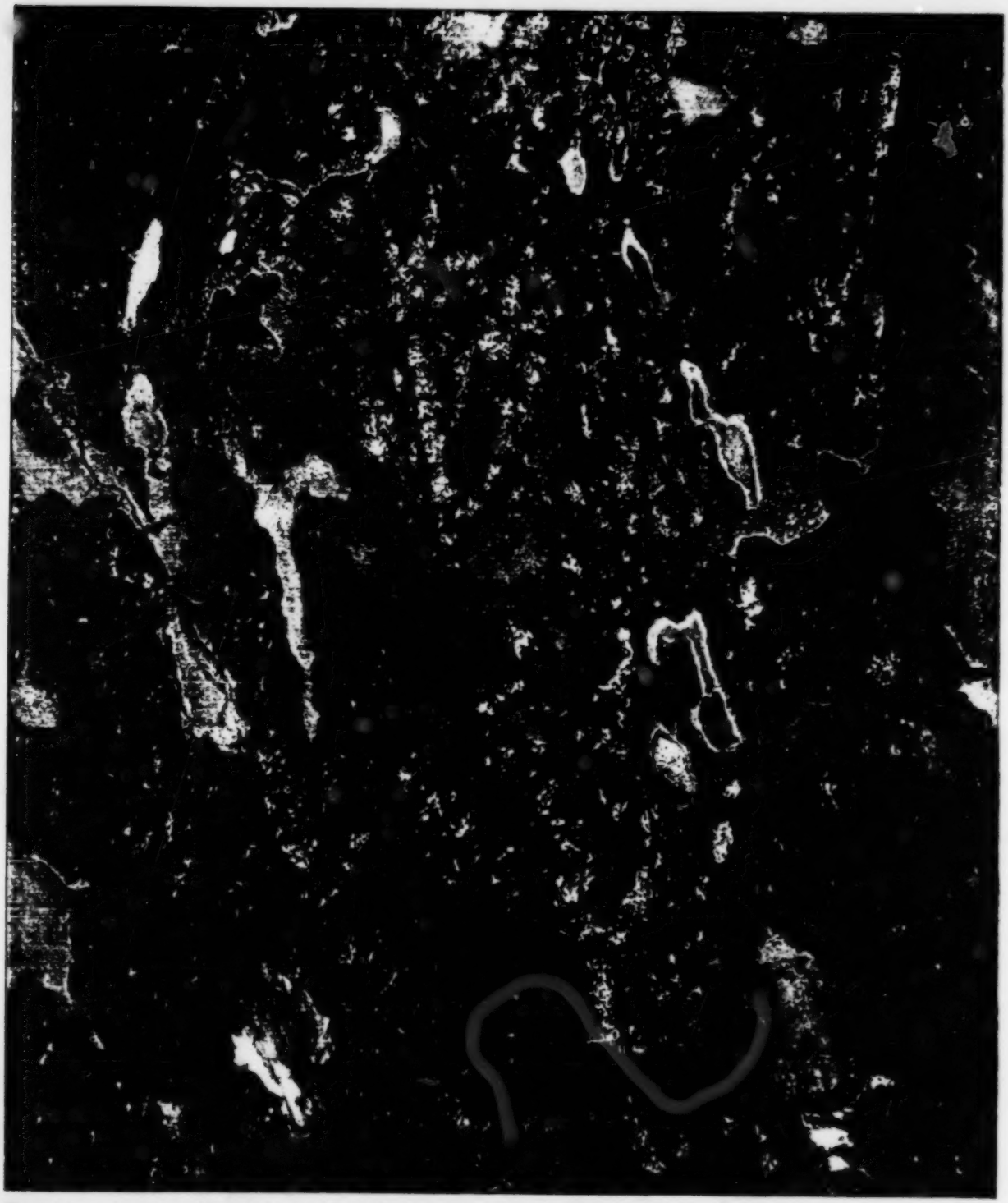

Figure 14. *Aerial view of Selected Sand and Gravel Resource Areas 32 and 33, northwest of Fort Frances, scale 1:15 840.*

Figure 15. *Aerial view of Selected Sand and Gravel Resource Areas 34 to 39, northwest of Fort Frances, scale 1:15 840.*

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CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in cooperation with the Coal Association of Canada.

Aggregate Resources Inventory of Northwest of Fort Frances Northern Ontario

by Staff[1] of the Engineering and Terrain Geology Section

[1]Project Supervisor: I. Szoke; field work and report by G.R. Jones; compilation and drafting by Staff of the Aggregate Assessment Office. Assistance with review provided by the Resident Geologist of the Kenora District of the Ministry of Northern Development and Mines. The Mineral Resources Staff of the Fort Frances District Office of the Ministry of Natural Resources assisted in the collection of data, field checking and review of this report.

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Abstract

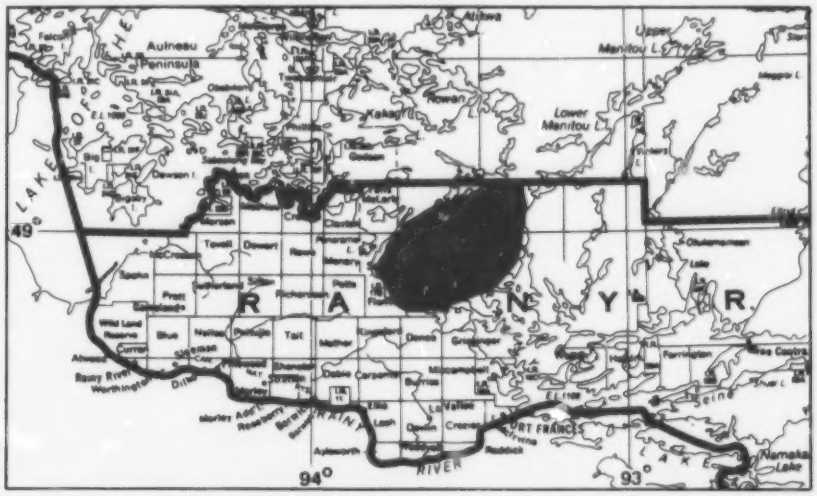

Figure 1. *Key map showing the location of the report area, northwest of Fort Frances, scale 1:1 584 000.*

This report includes an inventory and evaluation of aggregate resources in a remote area of northern Ontario, northwest of Fort Frances. The investigation was designed specifically to identify potential sources of road-building aggregate for the planning and future development of forest access roads. A detailed field investigation undertaken in the summer of 1988 and previous studies in the area, provide the framework for this study.

Forty-six of the most significant potential sources of road-building aggregate in the project area have been designated as Selected Sand and Gravel Resource Areas. These resource areas occupy 1810 acres (730 ha). An estimated 1700 acres (690 ha) are currently available for extraction, containing resources of approximately 64 million tons (58 million tonnes). They consist largely of esker, moraine, kame and other ice-contact features.

The most widespread potential sources of sand and gravel in the report area are lee side ice-contact features. These features were deposited on the lee side (southern side in this area) of bedrock knobs and ridges. Although these deposits are usually of limited areal extent, many are well situated within the two forest access road corridors proposed for the area. Substantially greater quantities of aggregate are available on a per deposit basis from the moraines and esker. These deposits form prominent ridges in the area. The moraines trend northwest and the esker is orientated in a northeast direction. Additional sand and gravel resources are available from kames and north- or northeast-trending ice-contact features.

The sand and gravel in the study area is generally well suited for most road-building uses. The material varies from sand, suitable for road subbase, to coarse crushable gravel. Factors which may limit aggregate quality in some deposits include the abundance of oversize clasts and the presence of fines. The oversize material can be removed or processed in a primary crusher. Selective extraction measures may be required to avoid layers containing excessive quantities of fines.

Till deposits and bedrock are also considered potential sources of granular material in the report area. Till was deposited by glacial ice which advanced in a southwesterly direction. The most readily produced aggregate product from till is granular fill. This material is required for road subgrade construction. The Precambrian age bedrock consists largely of granitic and metavolcanic rocks. Although the bedrock is generally considered to be a potential source of hard and durable aggregate, the higher costs associated with quarrying would inhibit quarry development for access road construction.

The bedrock dominated terrain in the Precambrian shield area northwest of Fort Frances is generally lacking in known sand and gravel deposits. Despite this scarcity, several deposits were discovered in the report area which are considered valuable potential sources of road-construction aggregate. The identification of these deposits prior to access road development should help decrease the costs associated with construction. Haulage distances may be reduced and aggregate shortages may be avoided in many areas. One area in which aggregate resources are extremely limited, however, is the area located north and west of Ottertail and West Jackfish lakes.

Résumé

Ce rapport comprend un inventaire et une estimation des ressources en agrégat dans une région isolée du nord de l'Ontario, au nord-ouest de Fort Frances. L'étude visait spécifiquement à identifier les sources possibles d'agrégat pour la plannification et la construction de routes d'accès forestières. Une étude détaillée sur le terrain, entreprise pendant l'été 1988, et les études préalables effectuées dans la région constituent la base de cette étude.

Parmi les plus importantes sources possibles d'agrégat pour la construction routière, quarante-six ont été désignées comme sites sélectionnés pour leurs ressources en sable et gravier. Ces sites occupent une surface de 1810 acres (730 ha). Une surface estimée de 1700 acres (690 ha) contenant environ 64 millions de tonnes (58 millions de tonnes métriques) sont disponibles pour l'extraction. Ces ressources proviennent sourtout d'eskers, de moraines, de kames et d'autres dépôts fluvio-glaciaires de contact.

Les sources potentielles en sable et gravier les plus répandues dans le secteur du rapport sont des dépôts fluvio-glaciaires de contact des côtés abrités du courant. Ces sédiments ont été accumulés du côté abrité des bosses et crêtes rocheuses (côté sud de ce secteur). Bien que ces dépôts soient habituellement d'étendues limitées, beaucoup sont favorablement situés entre les deux corridors d'accès forrestiers projetés dans ce secteur. En se basant sur des dépôts individuels, des agrégats en quantités substantiellement plus importantes peuvent se trouver dans les moraines et l'esker. Ces dépôts forment des crêtes saillantes dans le secteur. Les moraines sont d'orientation nord-ouest et l'esker est orienté vers le nord-est. Des ressources supplémentaires en sable et gravier provenant de kames et dépôts fluvio-glaciaires de contact orientés vers le nord ou le nord-est sont disponibles.

De manière générale, le sable et le gravier dans la région étudiée convient à la construction des routes. Le matériau varie du sable, qui convient pour la couche inférieure des routes, au gravier grossier concassable. La qualité des agrégats dans certains dépôts, peut être limitée par la présence de gros fragments et la présence de particules fines. Les fragments grossiers peuvent être enlevés ou concassés dans un broyeur primaire. Des méthodes d'extraction sélectives peuvent être nécessaires pour éviter les couches contenant trop de particules fines.

Dans le secteur étudié, les dépôts de till et le substratum rocheux sont aussi considérés comme étant des sources potentielles de granulat. Le till a été déposé par les glaciers au cours de la dernière avancée glacière vers le sud-ouest. Le produit le plus facilement extrait du till est du granulat de remplissage. Ce matériau est requis pour le sous-sol des routes. Le substratum rocheux d'âge précambrien est constitué surtout de roches granitiques et métavolcaniques. Bien que le substratum soit une source d'agrégat résistant et durable, les coûts d'extraction plus élevés font obstacle au développement de carrières pour la construction de voies d'accès.

Dans la partie du bouclier Précambrien au nord-ouest de Fort Frances prédomine un terrain à substratum rocheux généralement déficient en dépôts de sable et de gravier. Malgré cette déficience, plusieurs dépôts pouvant contenir des quantités intéressantes d'agrégat pour la construction routière ont été trouvés dans le secteur étudié. L'identification de ces dépôts avant le développement de routes d'accès devraient réduire les coûts de construction. Les distances d'acheminement peuvent être réduites et la pénurie d'agrégats peut être évitée dans beaucoup d'endroits. L'un des secteurs les plus dépourvus en ressources d'agrégat est celui au nord et à l'ouest du lac Ottertail et du lac West Jackfish.

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Introduction

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1987, the total tonnage of mineral aggregates extracted was 156 million tons (142 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Northern Development and Mines 1989).

This particular report was designed specifically to assess aggregate resources to aid in the planning and future development of forest access roads. The construction of forest access roads is an ongoing activity in Ontario. In the three-year period from 1986 to 1988, the average annual length of access roads built in Ontario, in which the Ontario government participated in funding, was approximately 1030 miles (1650 km) (B. Condie, Ontario Ministry of Natural Resources, personal communication, 1989). The assessment of aggregate resources prior to access road construction can help reduce the cost of development by providing information which could alleviate shortages during construction and reduce haulage distances.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of the resources.

This report includes an assessment of sand, gravel and till resources as well as a discussion on the potential for bedrock-derived aggregate. The most recent information available has been used to prepare the report. As new information becomes available, revisions may be necessary.

Part I - Inventory Methods

FIELD AND OFFICE METHODS

The methods used to prepare the report primarily involve the interpretation of aerial photographs and geological reports, and the field examination of potential resource areas. Aerial photographs are examined in detail at various scales under a stereoscope prior to and during field examination. They are examined to identify potential aggregate deposits. Information on potential aggregate deposits may also be obtained by examining published geological reports, maps and any other appropriate reports and papers (see References).

Pit information on file with the Soils and Aggregate Section of the Ontario Ministry of Transportation is also examined. In addition to pit and quarry locations, data contained in these files include field estimates of the depth, composition and "workability" of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. Records held by the Ontario Ministry of Natural Resources for pits and quarries licenced under the Pits and Quarries Control Act or developed on crown land under permission of a quarry permit also provide valuable information. The cooperation of the above-named groups in the compilation of inventory data is gratefully acknowledged.

Once the potential aggregate deposits are identified, they can be examined in the field. Field methods include examining the morphology of the features and assessing the aggregate revealed in natural and man-made exposures. Bedrock outcrop and erosional cuts alongside rivers and lakes are examples of natural exposures. Man-made exposures include subsurface materials uncovered by soil augering and test pitting techniques, and quarry and pit faces. Observations made at exposures include the depth or height of the exposure, and the proportion of gravel- and sand-sized fragments in the deposit. Observations are also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. The symbols for and locations of sample sites are noted on Map 1.

Deposits with potential for further extractive development are studied in greater detail. Representative sections in these deposits may be sampled in 25- to 100-pound (11 to 45 kg) units from existing pit faces or from test pits. The samples are analyzed for grain size distribution, and in some cases the Los Angeles abrasion and impact test, absorption, and Magnesium Sulphate soundness tests and petrographic analyses are carried out. Analyses are performed either in the Regional Laboratory, Ontario Ministry of Transportation, or in the Geoscience Laboratory, Ontario Geological Survey. Test hole drilling and excavation, and geophysical surveys may also be conducted in selected areas.

Topographic maps of the National Topographic System, at a scale of 1:50 000, are used as a compilation base for the field and office data. The information is then transferred to a base map, also at a scale of 1:50 000. These base maps are prepared by the Surveys, Mapping and Remote Sensing Branch, Ontario Ministry of Natural Resources with information taken from maps of the National Topographic System by permission of Energy, Mines and Resources Canada, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been established, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in acres. Two successive subtractions are made from the total area. The first subtraction is the number of acres unavailable because of the presence of permanent cultural features and their associated setback requirements (e.g., major roads and hydro lines). The second subtraction accounts for those areas that have been previously extracted. The remaining figure is the area currently available for extraction.

The thickness values used are an approximation of the deposit thickness, based on available subsurface data and topographic expression. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3 m) thick layer of sand and gravel, one acre (0.4 ha) in extent, assuming an average density of 110 pounds per cubic foot (1766 kilograms per cubic metre).

Tonnage = Available Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Resource estimates are calculated for selected resource areas. Resource estimates for other deposits are not calculated, however, the aggregate potential of these deposits is discussed in the report.

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany this report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with

the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel deposits are termed possible resources (see Glossary, Appendix B) in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975, p.7) and with the Association of Professional Engineers of Ontario (1976).

Part II - Data Presentation and Interpretation

MAP 1: DISTRIBUTION AND EVALUATION OF GRANULAR RESOURCES

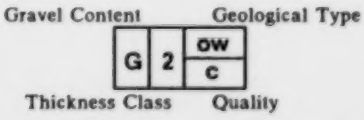
Map 1 gives a comprehensive inventory of granular resources in the report area. The map shows the extent and quality of glacial aggregate deposits within the study area and the present level of extractive activity. Those deposits which are considered the most significant in the report area are also identified on the map as selected areas.

A number of symbols appear on Map 1. Sand and gravel pits are identified by a numbered dot on the map and described in Table 1. Each description notes the location and estimated face height of the pit as well as the estimated percentage of gravel it contains.

Map 1 also presents a summary of available information related to the quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the Deposit and Texture Symbols which are found on the maps. The Deposit Symbol appears for each mapped sand and gravel deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

DEPOSIT SYMBOL

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for every sand and gravel deposit shown on Map 1. These components are illustrated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess silt and clay may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate (greater than 4.75 mm) makes up less than 35 percent of the whole deposit. "G" indicates that the deposit contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identifies the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identifies the main quality limitations that may be present in the deposit as discussed in the next section.

TEXTURE SYMBOL

The Texture Symbol provides a more detailed assessment of the grain size distribution of material sampled during field study. These symbols are derived from the information plotted on the aggregate grading curves found in the report. The relative amounts of gravel, sand, and silt and clay in the sampled material are shown graphically in the Texture Symbol by the subdivision of a circle into proportional segments. The following example shows a hypothetical sample consisting of 30 percent gravel, 60 percent sand, and 10 percent silt and clay:

EVALUATION OF GRANULAR RESOURCES

On the map, Selected Sand and Gravel Resource Areas are indicated by dark orange shading and are given a deposit number. The Selected Sand and Gravel Resource Areas represent the most significant potential sources of road-building aggregate in the study area. Those deposits consisting predominantly of till suitable for low specification aggregate use (fill) are indicated by light green shading. Although these deposits are not considered the best resources in the report area, they should be considered part of the area's total aggregate supply. These potential fill sources may be especially important in areas where selected deposits are scarce. Deposits not considered to be important resource areas (Low Potential Aggregate Sources), because of their low available resources, or because of possible difficulties in extraction, are shaded light orange. A dashed line around a deposit indicates a potential deposit delineated through aerial photograph interpretation.

The process by which deposits are evaluated and selected primarily involves the consideration of site specific criteria. Site specific criteria are related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development.

SITE SPECIFIC CRITERIA

Deposit Size

Ideally, selected deposits should contain large amounts of available sand and gravel. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the project area. Generally, deposits in Class 1 [greater than 20 feet (6 m) thick], and containing more than 35 percent gravel are considered to be the most favourable for development. Thinner deposits may be valuable in areas with low total resources.

Aggregate Quality

The limitations of natural aggregates for various uses result from variations in the lithology of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the deposit symbols for sand and gravel deposits on Map 1. They are: gravel content (G or S); fines (C); oversize (O); and lithology (L).

Three of the quality indicators deal with grain size distribution. The gravel content (G or S) indicates the suitability of aggregate for various uses. Deposits containing at least 35 percent gravel in addition to a minimum of 20 percent material greater than the 26.5 mm sieve are considered to be the most favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess fines (high silt and clay content) may severely limit the potential use of a deposit. Fines content in excess of 10 percent may impede drainage in road subbase aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent oversize material [greater than 4 inches (10 cm) in diameter] may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building aggregate, so it must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

Another indicator of the quality of an aggregate is lithology. Just as the unique physical and chemical properties of bedrock types determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high quality uses such as concrete and asphalt. Similarly, highly weathered, very porous and friable rock can restrict the quality of an aggregate. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol shows either "C", "O", or "L" or any combination of these indicators, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt is made to quantify the degree of limitation imposed. Assessment of the four indicators is made primarily from field observations and sample data.

Quality data may also appear in Table 3, where the results of the Ministry of Transportation (MTO) quality tests are listed by test type and sample location. The types of tests conducted and the test specifications are explained in Appendixes B and D, respectively.

Analyses of unprocessed samples obtained from pits or sample sites are plotted on grain size distribution graphs. On the graphs are the Ontario Ministry of Transportation's gradation specification envelopes for aggregate products: Granular Base Course A, B and C; Hot-Laid Asphaltic Sand Nos. 1, 2, 3, 4, and 8; and concrete sand. By plotting the gradation curves with respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product. These graphs, called Aggregate Grading Curves, follow the tables in the report.

Location and Setting

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made primarily on the basis of natural and man-made features which may limit or prohibit extractive development. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Permanent man-made features, such as roads, railways, power lines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation, as applicable.

BEDROCK RESOURCES

The Precambrian shield rocks in Ontario are generally more complex and variable than the Paleozoic rocks. They often show wide variations in mineralogy, texture (grain size), joint patterns and degree of weathering, even within specific rock types and over relatively short distances. As these factors are considered important in determining the suitability of the bedrock for use as aggregate, the aggregate potential may also vary considerably from location to location.

Careful selection is especially important if the bedrock is to be used as concrete aggregate. Deleterious chemical reactions may develop in the concrete which can lead to its eventual deterioration. Fortunately, these chemical reactions should not influence the use of bedrock-derived aggregate for such uses as roadbase material. However, highly weathered, very porous and friable rock should be avoided for all uses.

For these reasons, no specific bedrock resources have been selected for resource protection. A summary of the bedrock resources on a regional level is included in the Bedrock Geology and Resource Potential section.

Part III - Assessment of Aggregate Resources Northwest of Fort Frances

LOCATION AND ACCESS

The report area is located approximately 25 miles (40 km) northwest of Fort Frances in the districts of Rainy River and Kenora. The area extends from the northwestern shore of Rainy Lake, northwest to Burditt (Clearwater, local name) and Pipestone lakes. Senn, Fleming and Dance townships are situated along the southern and western boundaries of the area. The study area occupies approximately 150 000 acres (61 000 ha) and is covered by the Harris Lake (52 F/3), Kakagi Lake (52 F/4), Mainville Lake (52 C/14) and Northwest Bay (52 C/13) map sheets of the National Topographic System, at a scale of 1:50 000.

Road access is currently limited to the southwestern and northeastern edges of this remote area. Along the southwestern edge, Secondary Highway 613 provides access to Northwest Bay of Rainy Lake and Lake Despair, and Burditt Lake can be accessed from Secondary Highway 615. Cedar Narrows Road traverses the northeastern corner of the report area. A portage trail which branches off this road leads to Furlonge Lake. From Lake Despair, Burditt Lake and Furlonge Lake, a large network of lakes in the project area can be accessed with minor portaging. Major lakes within this network include Footprint, Jackfish, West Jackfish, Pipestone, Loonhaunt and Kaiashkons.

Tourism and forestry are the major activities in the area. Cottages are common along Burditt, Footprint, Jackfish and West Jackfish lakes and Lake Despair. Hunting and fishing camps are established on most major lakes. Parts of the report area have also been logged in the recent past, notably in the area between Burditt Lake, and Albert and Ottertail lakes. Additional logging is proposed in the future, consequently, the construction of forest access roads is necessary to access the timber.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The physiography of the area northwest of Fort Frances is typical of the Canadian Shield. Bedrock occurs at, or just below, the ground surface throughout much of the area. Bedrock ridges and knobs have a maximum local relief of about 200 feet (60 m) in the report area. Swamps are common in poorly drained areas between bedrock highs.

Glacial materials make up the remainder of the land surface. These deposits are related to the last major advance and melting of a continental ice sheet during the Late Wisconsinan Substage of the Pleistocene Epoch (informally known as the "Great Ice Age"). During this substage, a discontinuous cover of till was deposited throughout the project area by glacial ice which advanced in a southwesterly direction (Zoltai 1961, 1965; Bajc 1987, 1988; Bajc and Gray 1987; Cowan 1987; Minning 1988; Bajc et al. in preparation). This stony, silty sand till generally exists as a thin veneer over bedrock, although in several areas significant thicknesses can be observed. These thicker till accumulations often flank bedrock knobs. Till is not usually well suited for high specification aggregate uses as it often contains excess fines and abundant oversize clasts. It is considered, however, to be an important potential source of fill in the study area.

During temporary halts of the ice margin, as it melted northeastward, several moraines were laid down. These moraines form northwest-trending ridges. A major moraine, known as the Rainy Lake-Lake of the Woods Moraine (Zoltai 1961), is situated along the southwestern boundary of the report area. Significant aggregate resources also occur within moraines located near Furlonge and Gussie lakes, and between Loonhaunt and Kaiashkons lakes. Moraine ridges in the area may have local relief in excess of 40 feet (12 m). The aggregate available from the moraines is of variable quality. In some localities, clean sandy gravel suitable for a variety of aggregate uses is exposed, but in other places the aggregate consists of lower quality material containing abundant fines and/or oversize clasts.

An esker ridge and three kames were deposited by glacial meltwaters in the area. The esker was deposited by meltwaters flowing in a tunnel complex under the ice or in a re-entrant at the ice front. The esker ridge trends in a northeast direction near Calder Lake. Material ranging from sand to coarse gravel is exposed in this 10- to 50-foot (3 to 15 m) high ridge. Kames are mound-shaped features deposited by meltwaters, possibly in depressions or fissures on the ice surface or at its margin.

Deposits consisting of ice-contact stratified drift are widespread in the report area. Most of these features form ridges along the lee side (southern flank) of bedrock ridges and knobs. Lee side ice-contact features usually have local relief varying from 10 to 40 feet (3 to 12 m) high. Although these deposits are typically small, they are widely used northwest of Fort Frances as aggregate sources for access road development. Material exposed in these features usually ranges from medium sand to coarse gravel. Ice-contact material was also laid down within north- or northeast-trending bedrock controlled valleys. The features deposited northeast and southwest of the esker, and along Mile River, are examples of this type of deposit. They are typically relatively large features which may be flat lying or hummocky.

During deglaciation, much of the land surface was submerged beneath waters of glacial Lake Agassiz. In the deep water of glacial lakes, silt and clay were deposited. Glaciolacustrine plain sediments consisting pre-

dominantly of silty fine sand were laid down in the shallower parts of the lakes. These glaciolacustrine sands are generally too fine for most aggregate uses and the deposits usually contain only extremely limited aggregate resources. Some of the aforementioned moraine, kame and ice-contact deposits may have been deposited beneath the surface of the glacial lakes. Cowan (1987) and Minning (1988) report that a number of moraines, located north and northwest of the report area, were deposited in contact with glacial lake waters.

Erosional activity has been minimal since the disappearance of the ice sheet and lowering of lake waters to present-day levels. Organic deposits have been developed in depressions in the land surface, and alluvium has been laid down along the courses of creeks and rivers.

EXTRACTIVE ACTIVITY

Eleven sand and gravel pits have been opened in the report area. The pits have been developed along highways and bush roads situated near the southern and northern borders of the report area. During field investigations, the pits were at various stages of development. Many of the pits have been worked recently, but several sites have been inactive for a considerable period of time.

SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 1 indicates the deposits which contain granular materials (sand, gravel and till). These deposits have varying potential for extraction. Material in the deposits ranges from till, suitable for use as fill, to sand and gravel, suitable for pit-run and crusher-run uses. The amount of granular material available in different features also varies. For example, most glaciolacustrine plain deposits are very thin [less than 5 feet (1.5 m) thick] in comparison to moraine ridges which can be over 40 feet (12 m) high. Only the most significant potential sources of road-building aggregate have been designated as Selected Sand and Gravel Resource Areas on Map 1. These selected deposits are also shown in more detail in Figures 2 to 18.

The Selected Sand and Gravel Resource Areas consist predominantly of moraine, esker, kame, and other ice-contact features. They contain aggregate resources considered at least potentially suitable for the production of road subbase. With the exception of a small number of features, the selected deposits average over 8 feet (2 m) in thickness. The Selected Sand and Gravel Resource Areas occupy an available area of 1700 acres (690 ha). They contain possible sand and gravel resources of approximately 64 million tons (58 million tonnes).

The major sand and gravel resources within the project area are Selected Sand and Gravel Resource Areas 2, 8, 12, 20, 40, 44, 45 and 46. Each of these areas contain potential resources of at least one million tons (1 million tonnes) of aggregate. Resource Areas 1, 5, 6, 14, 24, 41 and 42 also contain significant resources of between 500 000 and 1 million tons (455 000 and 1 million tonnes) per deposit. The remaining 31 deposits each contain potential reserves of less than 500 000 tons (455 000 tonnes). Although the quantity and quality of the aggregate in a deposit are major considerations for extractive development, the location of a particular resource in relation to the road being developed is also an important concern. Therefore, well situated, small deposits may prove to be of greater value than poorly located, large deposits.

Information used to determine the significance of a sand and gravel deposit includes observations on geological origin, topographic expression and subsurface materials as well as sample analysis. Because of the remote location of many of these deposits, subsurface investigation was usually restricted to manual techniques of soil augering and test pitting using a shovel. For this reason, the depth of subsurface investigation was limited to 4 feet (1.2 m) in most deposits. As detailed information is usually unavailable at greater depths, the resource estimates for the selected deposits should not be treated as proven resources but as possible resources (see Glossary). Additional subsurface investigation using power equipment is recommended prior to extraction in all deposits.

Quaternary geology mapping by Bajc et al. (in preparation) provided the framework for the detailed aggregate study in the southwestern part of the project area. Reconnaissance level geological studies by Zoltai (1961, 1965) and Minning (1988), and engineering and terrain studies by Roed (1980a, 1980b) also cover the area.

SELECTED SAND AND GRAVEL RESOURCE AREA 1

Location: North of Furlonge Lake along Cedar Narrows Road (Figure 2)

Glacial Origin: Ice-contact

Topography: The deposit exhibits hummocky topography with maximum relief of approximately 25 feet (8 m).

Subsurface Data: Two pits have been opened in the deposit. Faces in pit no. 1 ranged from 10 to 15 feet (3 to 5 m) high and exposed gravelly sand. Ten to twenty feet (3 to 6 m) of fine to medium gravel is revealed in the faces of pit no. 2. The gravel content of this material ranged between 40 and 60 percent.

Sample Data: A sample taken from pit no. 2 contained 56 percent gravel, 41 percent sand and 3 percent fines (Figure 19a). Twenty-three percent of the aggregate was crushable. Petrographic analysis and abrasion testing indicated the gravel was hard and durable (Table 3).

General Aggregate Potential: The aggregate appears well suited for the extraction of both pit-run and crusher-run products. Further subsurface investigation should be conducted in the adjoining deposit as it may have similar resource potential.

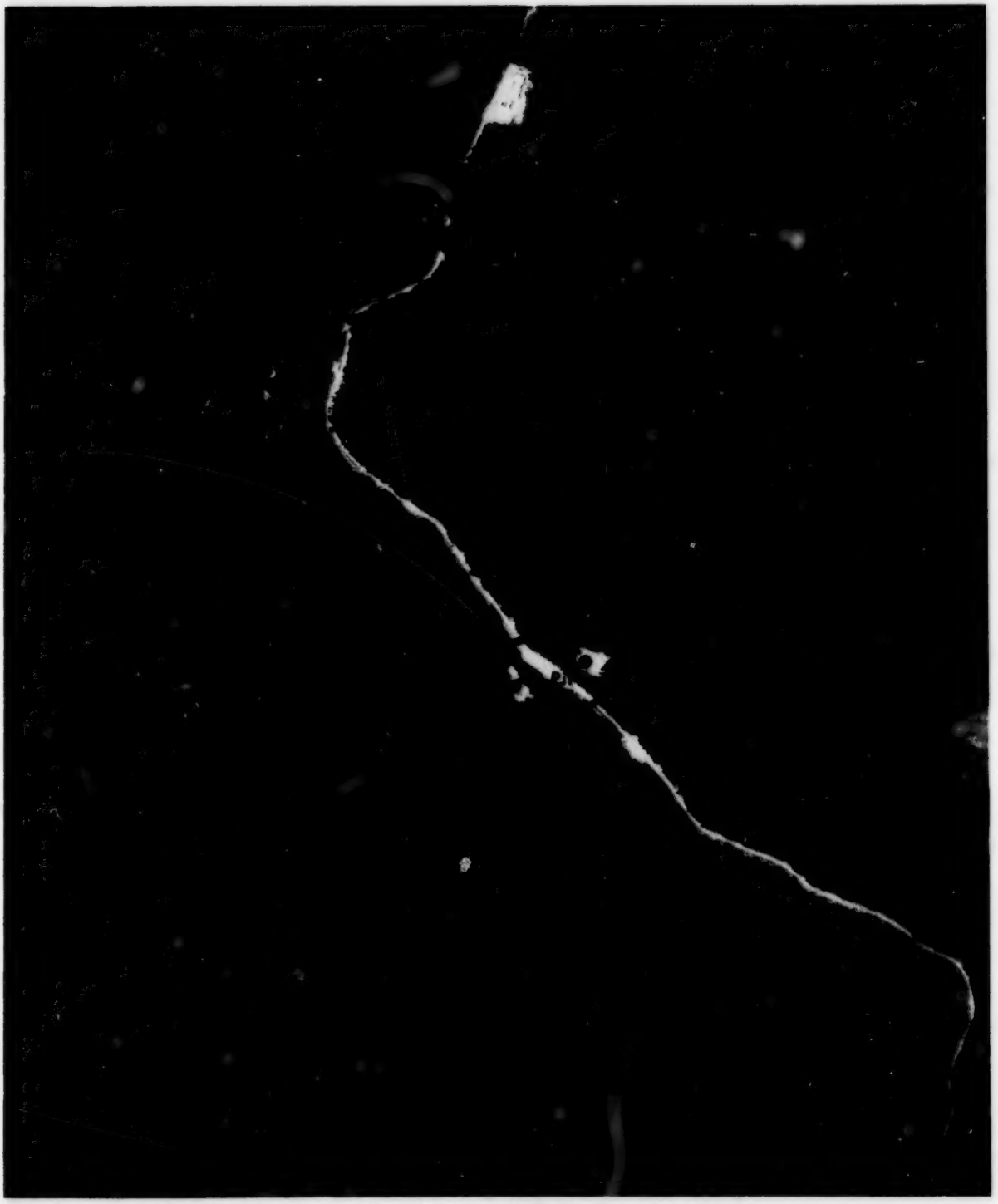


Figure 2. *Aerial view of Selected Sand and Gravel Resource Area 1, northwest of Fort Frances, scale 1:15 840.*

Resource Estimates: Area - 26 acres (10 ha)
Cultural Setbacks - 2.0 acres (0.8 ha)
Extracted Area - 6 acres (2 ha)
Available Area - 18 acres (7 ha)
Average Deposit Thickness - 12 feet (4 m)
Available Aggregate - 540 000 tons (490 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 2

Location: Between Furlonge Lake and Lower Furlonge Lake (Figure 3)

Glacial Origin: Moraine

Topography: The feature forms a northwest-trending ridge with local relief varying from 10 to over 50 feet (3 to over 15 m).

Subsurface Data: Two test pits were excavated to depths of 3 feet (1 m) revealing gravelly sand to sandy gravel with an estimated 30 to 40 percent coarse material.

Sample Data: A sample taken from one of the test pits (Sample FF-SS-1) contained 30 percent gravel, 66 percent sand and 4 percent fines (Figure 20a). There was insufficient gravel of suitable size for crushing purposes.

General Aggregate Potential: The deposit is probably well suited for the production of pit-run aggregate. Till may be encountered in the northwestern tip. Boulders are also common in this area.

Resource Estimates: Area - 17 acres (7 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 17 acres (7 ha)
Average Deposit Thickness - 25 feet (8 m)
Available Aggregate - 1 million tons (1 million tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 3

Location: Along the north shore of Kaiashkons Lake (Figure 3)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit forms an east-trending ridge with southern slopes in excess of 10 feet (3 m) high.

Subsurface Data: Two test pits were excavated to depths of 3 feet (1 m) in the feature. The western test pit (FF-SS-2) exposed clean medium sand. Fine to medium sand was uncovered in the eastern test pit (FF-SS-3).

Sample Data: Sample FF-SS-2 consisted of sand well suited for road subbase applications (Figure 20a). The aggregate was finer in sample FF-SS-3 and acceptable for use as fill (Figure 20a).

General Aggregate Potential: Granular subbase and fill are likely to be the most readily produced aggregate from the deposit.

Resource Estimates: Area - 8 acres (3 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 8 acres (3 ha)
Average Deposit Thickness - 15 feet (5 m)
Available Aggregate - 300 000 tons (270 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 4

Location: Approximately 0.6 miles (1.0 km) south of Cedar Narrows Road along the western shore of Gussie Lake (Figure 4)

Glacial Origin: Moraine

Topography: The feature forms a ridge which has local relief of 15 to 20 feet (5 to 6 m).

Subsurface Data: A test pit excavated into the crest of the ridge revealed 3 feet (1 m) of fine to medium gravel with a clean medium to coarse sand matrix. The material was similar to the aggregate sampled from pit no. 5 (see Resource Area 6).

General Aggregate Potential: The deposit appears well suited for pit-run uses.

Resource Estimates: Area - 9 acres (4 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 9 acres (4 ha)
Average Deposit Thickness - 15 feet (5 m)
Available Aggregate - 340 000 tons (310 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 5

Location: Approximately 0.5 to 0.8 miles (0.8 to 1.3 km) south of Cedar Narrows Road along the western shore of Gussie Lake (Figure 4)

Glacial Origin: Moraine

Topography: Hummocky

Subsurface Data: Soil augering in a 10- to 15-foot (3 to 5 m) high hummock revealed sand. Sand and gravel is revealed in exposures along the shore of Gussie Lake.

General Aggregate Potential: Aggregate quality is expected to be variable. The highest potential areas are hummocks within the area. Low-lying swampy depressions and bedrock outcrops may occur locally.

Resource Estimates: Area - 39 acres (16 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 39 acres (16 ha)
Average Deposit Thickness - 8 feet (2 m)
Available Aggregate - 780 000 tons (710 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 6

Location: The deposit is located approximately 0.7 miles (1.1 km) south of Cedar Narrows Road. It is accessible via a bush road which branches off Cedar Narrows Road at Cedar Narrows. (Figure 4)

Glacial Origin: Moraine

Topography: The feature forms a prominent ridge which rises over 40 feet (12 m) above the surrounding terrain.

Figure 3. *Aerial view of Selected Sand and Gravel Resource Areas 2 and 3, northwest of Fort Frances, scale 1:15 840.*

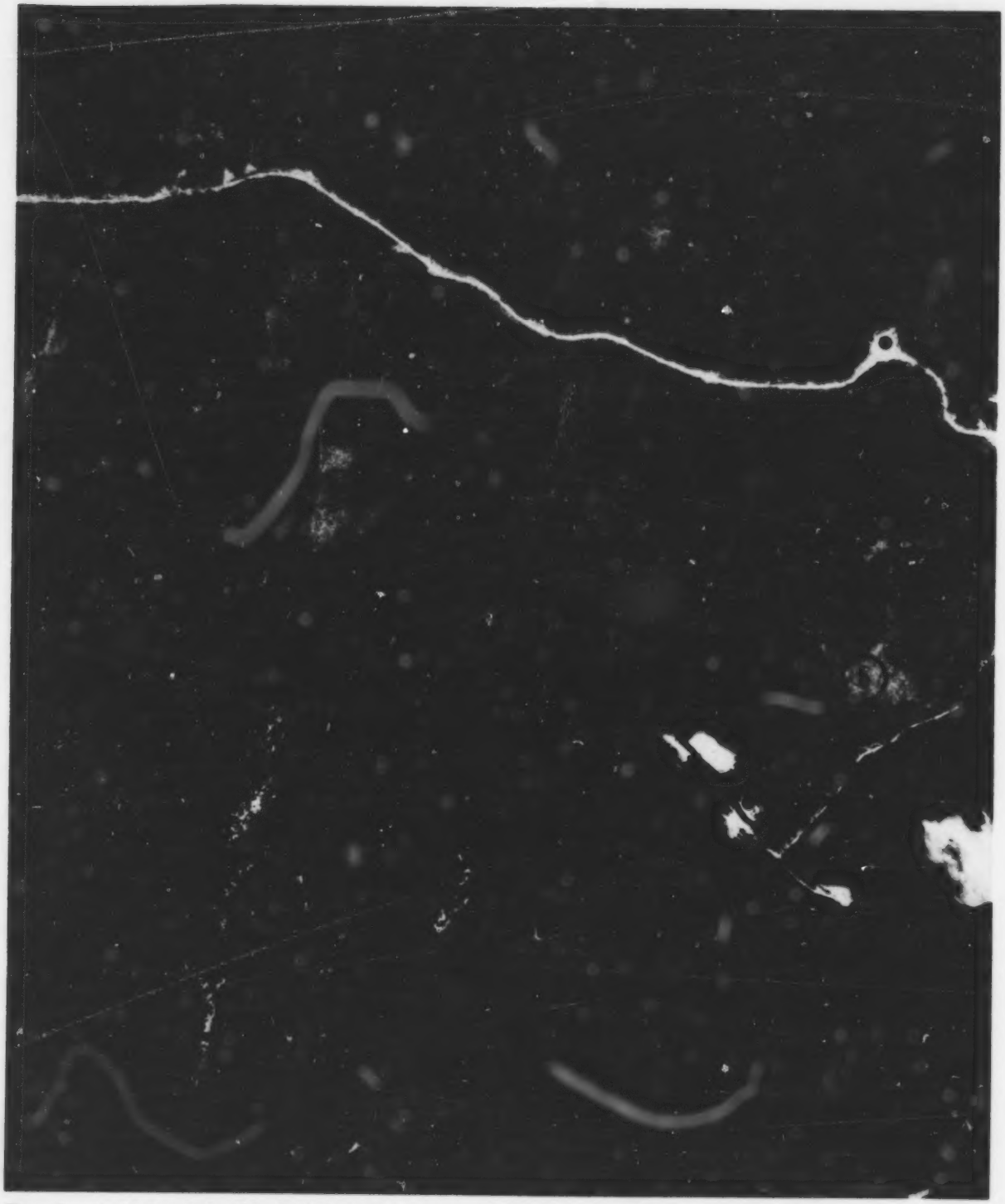


Figure 4. *Aerial view of Selected Sand and Gravel Resource Areas 4, 5 and 6, northwest of Fort Frances, scale 1:15 840.*

Subsurface Data: Pit no. 5 was worked in two levels. Faces in the upper level revealed 30 feet (9 m) of fine to medium gravel. The gravel content of these faces ranged from 50 to 60 percent. Fifteen feet (5 m) of similar aggregate was observed in the lower level. The aggregate was overlain by silt and clay layers up to 4 feet (1.2 m) thick in one section of the pit.

Sample Data: A sample from pit no. 5 contained 55 percent gravel, 43 percent sand and 2 percent fines (Figure 19a). The material was marginally too fine for crushing purposes. Petrographic analysis and abrasion testing indicated the gravel was hard and durable.

General Aggregate Potential: The aggregate is considered well suited for pit-run uses. Selection and sand control may be required for crushing. Silt and clay layers should be removed prior to extraction of the underlying aggregate.

Resource Estimates: Area - 12 acres (5 ha)
Cultural Setbacks - none
Extracted Area - 3 acres (1.2 ha)
Available Area - 9 acres (4 ha)
Average Deposit Thickness - 40 feet (12 m)
Available Aggregate - 900 000 tons (820 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 7

Location: Near the northwestern shore of Kaiashkons Lake (Figure 5)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit rises steeply towards the north to a maximum height of 30 feet (9 m). A prominent bedrock ridge outcrops along the northern border of the feature.

Subsurface Data: Test pitting in the resource area revealed 3 feet (1 m) of medium to coarse gravel with a medium to coarse sand matrix. The material contained an estimated 60 percent gravel and abundant boulders and cobbles.

General Aggregate Potential: The aggregate appears well suited for crushing. Oversize material may have to be removed for pit-run uses.

Resource Estimates: Area - 9 acres (4 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 9 acres (4 ha)
Average Deposit Thickness - 20 feet (6 m)
Available Aggregate - 450 000 tons (410 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 8

Location: Between Loonhaunt and Kaiashkons lakes (Figure 6)

Glacial Origin: Moraine

Topography: The feature exhibits variable relief with ridges and hummocks rising from 15 to over 50 feet (5 to over 15 m) above the surrounding terrain.

Subsurface Data: Three test pits were excavated in the resource area. One test pit was excavated on the slope of a 40- to 50-foot (12 to 15 m) high ridge situated just north of the portage trail linking Loonhaunt and Kaiashkons lakes. Three feet (1 m) of medium gravel with approximately 50 to 60 percent gravel was uncovered in the pit. Another test pit was excavated in the central part of the deposit. It revealed 1.5 feet (0.4 m) of dirty fine sand over 1.5 feet (0.4 m) of sandy fine gravel. The lower gravel unit contained between 30 and 40 percent gravel. Sandy gravel was exposed in the third test pit which was excavated into a 15-foot (5 m) high ridge in the southeast corner of the deposit.

General Aggregate Potential: The deposit is considered to be an excellent potential source of both pit-run and crusher-run aggregate products.

Resource Estimates: Area - 44 acres (18 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 44 acres (18 ha)
Average Deposit Thickness - 25 feet (8 m)
Available Aggregate - 3 million tons (3 million tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 9

Location: Approximately 0.4 miles (0.6 km) north of Sphene Lake (Figure 7)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit rises steeply towards the north and averages an estimated 15 feet (5 m) in thickness. It flanks a prominent bedrock ridge which outcrops along the northern boundary of the feature.

Subsurface Data: Two test pits were excavated in the deposit. One test pit revealed 3 feet (1 m) of fine to coarse gravel over clay of undetermined thickness. Three feet (1 m) of fine to coarse gravel with approximately 60 percent gravel was revealed in the other test pit.

General Aggregate Potential: Although the aggregate appears well suited for road-building uses, clay seams or pockets within the deposit should be avoided during extraction. Oversize clasts may have to be removed for pit-run uses.

Resource Estimates: Area - 4.0 acres (1.6 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 4.0 acres (1.6 ha)
Average Deposit Thickness - 15 feet (5 m)
Available Aggregate - 150 000 tons (136 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 10

Location: Approximately 1.9 miles (3.0 km) east of Bone Lake in the central part of the report area (Figure 8)

Glacial Origin: Lee side ice-contact feature

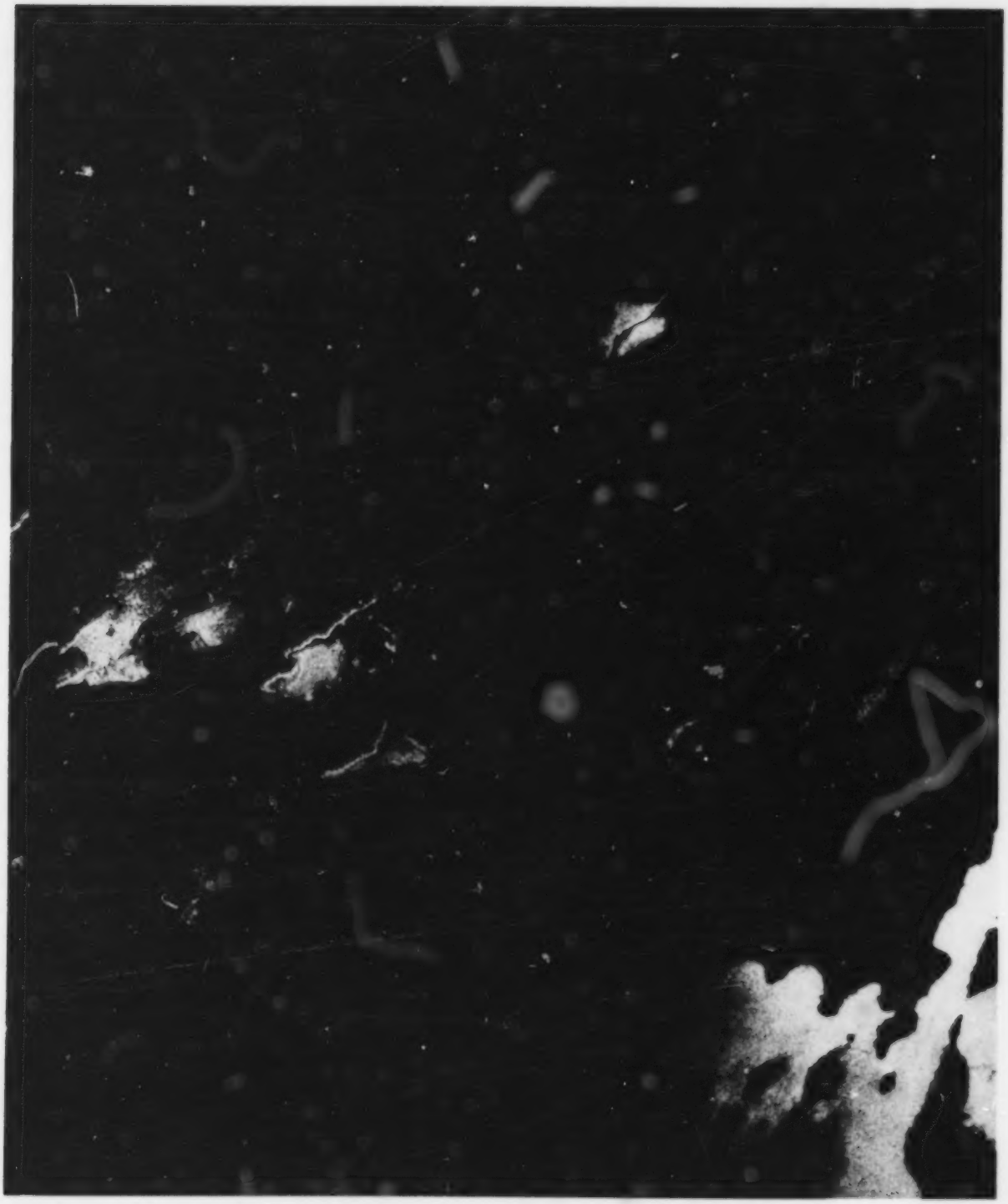


Figure 5. *Aerial view of Selected Sand and Gravel Resource Area 7, northwest of Fort Frances, scale 1:15 840.*

Figure 6. *Aerial view of Selected Sand and Gravel Resource Area 8, northwest of Fort Frances, scale 1:15 840.*

Figure 7. *Aerial view of Selected Sand and Gravel Resource Area 9, northwest of Fort Frances, scale 1:15 840.*

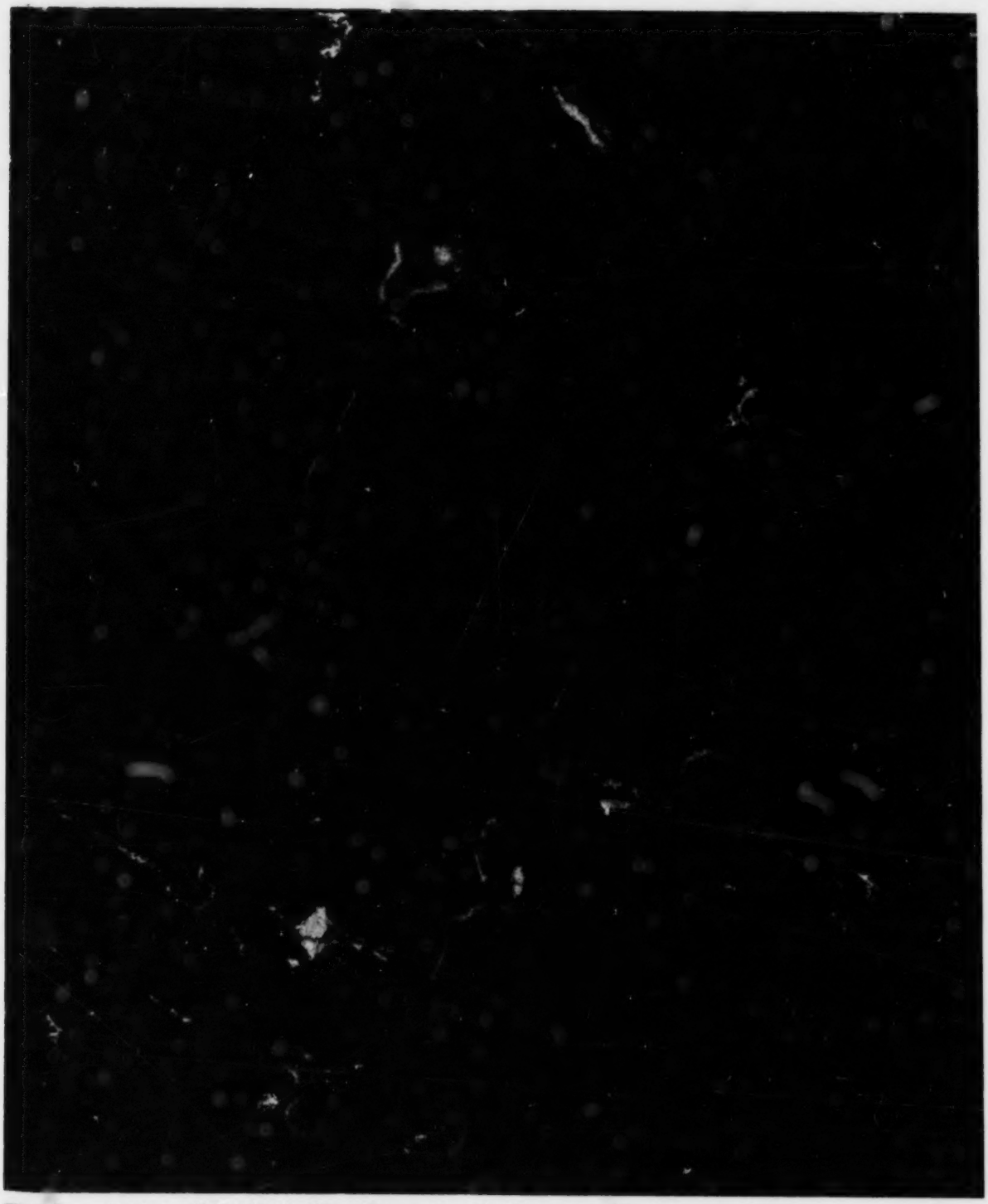


Figure 8. *Aerial view of Selected Sand and Gravel Resource Areas 10 to 16, northwest of Fort Frances, scale 1:15 840.*

Topography: The deposit rises to a height of over 20 feet (6 m) above the valley floor. A northwest-trending bedrock ridge outcrops along the northwestern boundary of the feature.

Subsurface Data: A test pit exposed 3 feet (1 m) of medium to coarse gravel with a medium to coarse sand matrix. The material contained an estimated [illegible] to 65 percent gravel.

General Aggregate Potential: The deposit appears well suited for the extraction of limited amounts of road-building aggregate. Oversize clasts may have to be removed for pit-run uses.

Resource Estimates: Area - 1.0 acre (0.4 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 1.0 acre (0.4 ha)
Average Deposit Thickness - 15 feet (5 m)
Available Aggregate - 37 500 tons (34 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 11

Location: Approximately 1.6 miles (2.6 km) east of Bone Lake in the central part of the report area (Figure 8)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit rises to a maximum height of 8 feet (2 m) above the valley floor and flanks a bedrock ridge which is exposed along its northern border.

Subsurface Data: Three feet (1 m) of slightly dirty fine gravel was uncovered in a test pit.

General Aggregate Potential: This deposit is considered to be a potential source of low specification aggregate such as fill and road subbase. Variable amounts of till may occur within the deposit.

Resource Estimates: Area - 1.7 acres (0.7 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 1.7 acres (0.7 ha)
Average Deposit Thickness - 6 feet (2 m)
Available Aggregate - 25 500 tons (23 100 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 12

Location: Approximately 1.6 miles (2.6 km) east of Bone Lake in the central part of the report area (Figure 8)

Glacial Origin: Ice-contact

Topography: The feature is situated within a north-trending, bedrock controlled depression. The deposit is flat lying on the valley floor. Along the eastern boundary of the deposit, where it flanks bedrock, a 15- to 25-foot (5 to 8 m) high ridge rises above the valley floor.

Subsurface Data: A test pit was excavated in the ridge along the deposit's eastern boundary just south of Resource Area 13. Clean, sandy gravel was exposed in the test pit. Further south along the ridge, at a position about 0.1 mile (0.2 km) south of Resource Area 13 towards Resource Area 14, fine sand was revealed by soil augering. This fine sand unit was 2 feet (0.6 m) thick and underlain by coarse granular material. Soil augering in the broad, flat-lying area west of Resource Area 14 revealed 3 feet (1 m) of clean fine to medium sand.

General Aggregate Potential: The deposit is considered to be an excellent potential source of pit-run aggregate. In places where fine sand layers occur the aggregate may be suitable only for use as fill.

Resource Estimates: Area - 38 acres (15 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 38 acres (15 ha)
Average Deposit Thickness - 12 feet (4 m)
Available Aggregate - 1 million tons (1 million tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 13

Location: Approximately 1.6 miles (2.6 km) east of Bone Lake in the central part of the report area (Figure 8)

Glacial Origin: Kame

Topography: The deposit is a mound-shaped feature with maximum local relief of 20 feet (6 m).

Subsurface Data: Excavation into the crest of the mound revealed 3 feet (1 m) of coarse gravel with approximately 70 to 80 percent coarse material. Abundant cobbles and boulders were noted.

General Aggregate Potential: The aggregate is considered well suited for crushing. Oversize clasts may have to be removed for pit-run uses.

Resource Estimates: Area - 1.2 acres (0.5 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 1.2 acres (0.5 ha)
Average Deposit Thickness - 15 feet (5 m)
Available Aggregate - 45 000 tons (41 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 14

Location: Approximately 1.6 miles (2.6 km) east of Bone Lake in the central part of the report area (Figure 8)

Glacial Origin: Lee side ice-contact feature

Topography: The feature is a steeply sloping, 30-foot (9 m) high ridge which flanks bedrock along its northern boundary.

Subsurface Data: Test pits revealed 3 feet (1 m) of predominantly fine to medium gravel. The gravel content ranged from 50 to 60 percent.

General Aggregate Potential: The feature appears to be an excellent potential source of at least pit-run aggregate.

Resource Estimates: Area - 7 acres (3 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 7 acres (3 ha)
Average Deposit Thickness - 30 feet (9 m)
Available Aggregate - 520 000 tons (470 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 15

Location: Approximately 1.2 miles (1.9 km) east of Bone Lake in the central part of the report area (Figure 8)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit consists of a 10- to 15-foot (3 to 5 m) high ridge which flanks bedrock along the northern border.

Subsurface Data: Fine to coarse gravel was revealed by shallow test pitting.

General Aggregate Potential: The deposit is suitable for the extraction of limited amounts of road-building aggregate. Variable amounts of till may be associated with the deposit.

Resource Estimates: Area - 0.6 acres (0.2 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 0.6 acres (0.2 ha)
Average Deposit Thickness - 12 feet (4 m)
Available Aggregate - 18 000 tons (16 300 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 16

Location: Approximately 0.9 miles (1.4 km) east of Bone Lake in the central part of the report area (Figure 8)

Glacial Origin: Kame

Topography: The deposit consists of a 10-foot (3 m) high mound. Boulders are common on the surface of the feature.

Subsurface Data: Sandy fine gravel was revealed by soil augering.

General Aggregate Potential: The deposit is likely suitable for the extraction of pit-run aggregate. Variable amounts of till may occur within the deposit. Oversize clasts may have to be removed for pit-run uses.

Resource Estimates: Area - 1.5 acres (0.6 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 1.5 acres (0.6 ha)
Average Deposit Thickness - 10 feet (3 m)
Available Aggregate - 37 500 tons (34 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 17

Location: Approximately 0.6 miles (1.0 km) southwest of Bone Lake in the central part of the report area (Figure 9)

Glacial Origin: Ice-contact

Topography: The deposit consists of 10- to 25-foot (3 to 8 m) high ridges deposited within a northeast-trending, bedrock controlled valley.

Subsurface Data: Coarse gravel was observed within test pits excavated into the crest of one of the ridges.

General Aggregate Potential: The material is likely well suited for a variety of aggregate products. Oversize clasts may have to be removed for pit-run uses.

Resource Estimates: Area - 9 acres (4 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 9 acres (4 ha)
Average Deposit Thickness - 15 feet (5 m)
Available Aggregate - 340 000 tons (310 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 18

Location: Approximately 0.3 miles (0.5 km) east of Whistle Bay of Loonhaunt Lake in the central part of the report area (Figure 9)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit rises between 15 and 30 feet (5 and 9 m) above the valley floor. Bedrock is exposed along the feature's northern boundary.

Subsurface Data: The excavation of a 3-foot (1 m) deep test pit uncovered fine to medium gravel with approximately 60 to 65 percent coarse material. The average size of the gravel was between 0.75 and 1.0 inches (1.9 and 2.5 cm).

General Aggregate Potential: The deposit is considered to be a potential source of pit-run aggregate and a marginal source of crusher-run products.

Resource Estimates: Area - 4.6 acres (1.9 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 4.6 acres (1.9 ha)
Average Deposit Thickness - 20 feet (6 m)
Available Aggregate - 230 000 tons (209 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 19

Location: East of Whistle Bay of Loonhaunt Lake in the central part of the report area (Figure 9)

Glacial Origin: Lee side ice-contact feature

Topography: The feature consists of an 8-foot (2 m) high ridge which flanks a bedrock knob.

Subsurface Data: Soil augering revealed 3 feet (1 m) of clean, medium sand.

General Aggregate Potential: The sand has the potential for use as road subbase and fill.

Resource Estimates: Area - 1.0 acres (0.4 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 1.0 acres (0.4 ha)
Average Deposit Thickness - 8 feet (2 m)
Available Aggregate - 20 000 tons (18 100 tonnes)

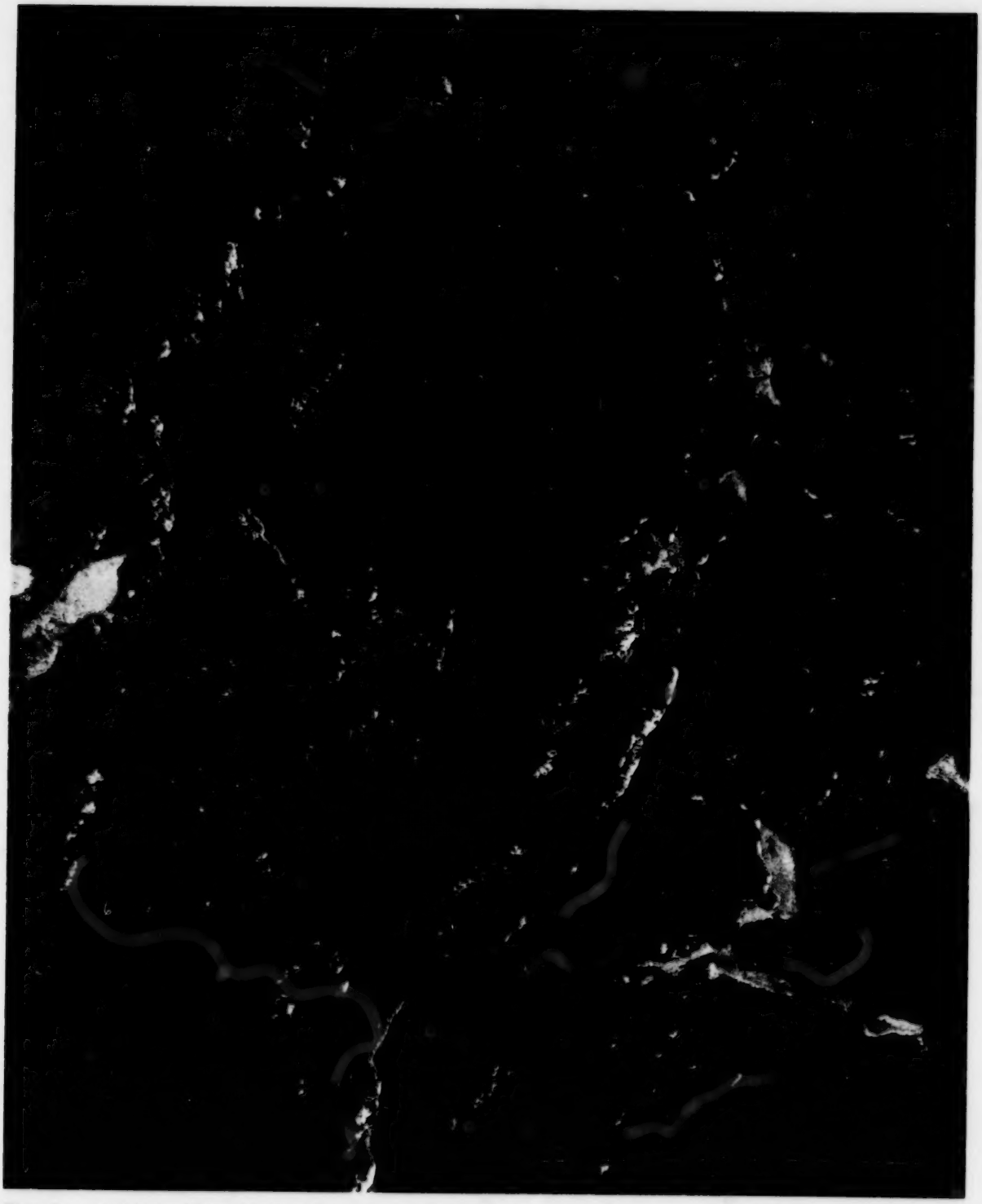


Figure 9. *Aerial view of Selected Sand and Gravel Resource Areas 17 to 21, northwest of Fort Frances, scale 1:15 840.*

SELECTED SAND AND GRAVEL RESOURCE AREA 20

Location: Along the north shore of Calder Lake (Figure 9)

Glacial Origin: Esker

Topography: The esker forms a prominent ridge within a northeast-trending, bedrock controlled valley. Three kettle depressions are associated with this 0.9-mile (1.4 km) long ridge. The northern, 0.4-mile (0.6 km) long, section of the ridge rises approximately 10 to 20 feet (3 to 6 m) above the surrounding terrain. The ridge becomes much higher for a length of 0.2 miles (0.3 km) south of the northern 0.4-mile (0.6 km) section. Within this 0.2-mile (0.3 km) distance, the ridge rises to over 50 feet (15 m) above the floor of an adjacent kettle depression. The southernmost parts of the ridge exhibit local relief between 15 and 20 feet (5 and 6 m). Boulders are common on the surface of the esker.

Subsurface Data: Test pitting and soil augering techniques revealed aggregate ranging from sand to coarse gravel. At one location, over 2 feet (0.6 m) of clay was observed overlying the aggregate.

Sample Data: Sample FF-SS-4 was taken from one test pit and revealed 19 percent gravel, 79 percent sand and 2 percent fines (Figure 21a).

General Aggregate Potential: The esker is considered an excellent potential source of aggregate suitable for a variety of road-building products. Clay layers should be avoided in some parts of the deposit and oversize clasts may have to be removed for pit-run uses.

Resource Estimates: Area - 35 acres (14 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 35 acres (14 ha)
Average Deposit Thickness - 20 feet (6 m)
Available Aggregate - 2 million tons (2 million tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 21

Location: Approximately 0.6 miles (1.0 km) south of Whistle Bay of Loonhaunt Lake in the central part of the report area (Figure 9)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit consists of a ridge up to 25 feet (8 m) high which flanks bedrock.

Subsurface Data: Three feet (1 m) of clean sandy fine gravel was revealed in a test pit. The material contained approximately 35 percent gravel.

General Aggregate Potential: This resource area is considered well suited as a potential source of pit-run material.

Resource Estimates: Area - 1.2 acres (0.5 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 1.2 acres (0.5 ha)
Average Deposit Thickness - 15 feet (5 m)
Available Aggregate - 45 000 tons (41 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 22

Location: Approximately 0.3 miles (0.5 km) west of Calder Lake (Figure 10)

Glacial Origin: Ice-contact

Topography: The deposit is a flat lying feature deposited on the floor of a northeast-trending, bedrock controlled valley.

Subsurface Data: Three feet (1 m) of clean, fine to medium sand was revealed by soil augering.

General Aggregate Potential: The aggregate is probably suitable for use as road subbase and fill.

Resource Estimates: Area - 11 acres (4 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 11 acres (4 ha)
Average Deposit Thickness - 8 feet (2 m)
Available Aggregate - 220 000 tons (200 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 23

Location: Between Calder and Jackfish lakes (Figure 10)

Glacial Origin: Kame

Topography: The deposit is mound shaped with maximum local relief of 30 to 40 feet (9 to 12 m).

Subsurface Data: An excavation into the crest of the mound uncovered 3 feet (1 m) of coarse gravel with abundant cobbles and boulders. The gravel content of the material ranged from 60 to 75 percent.

General Aggregate Potential: The aggregate is considered well suited for crushing. Oversize clasts may have to be removed for pit-run uses.

Resource Estimates: Area - 1.2 acres (0.5 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 1.2 acres (0.5 ha)
Average Deposit Thickness - 20 feet (6 m)
Available Aggregate - 60 000 tons (54 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 24

Location: Along the eastern shore of Jackfish Lake (Figure 10)

Glacial Origin: Ice-contact

Topography: Local relief of the deposit is generally 10 to 12 feet (3 to 4 m). Near the northern tip of the feature it reaches a maximum relief of 20 feet (6 m). The deposit flanks a bedrock ridge along its eastern border.

Subsurface Data: A test pit was excavated in the northern part of the deposit at sample site FF-SS-5. It exposed 3 feet (1 m) of coarse gravel. Three feet (1 m) of medium sand was revealed by soil augering in the central part of the feature. Medium to coarse gravel was observed in lakeside exposures along the southern tip of the deposit.

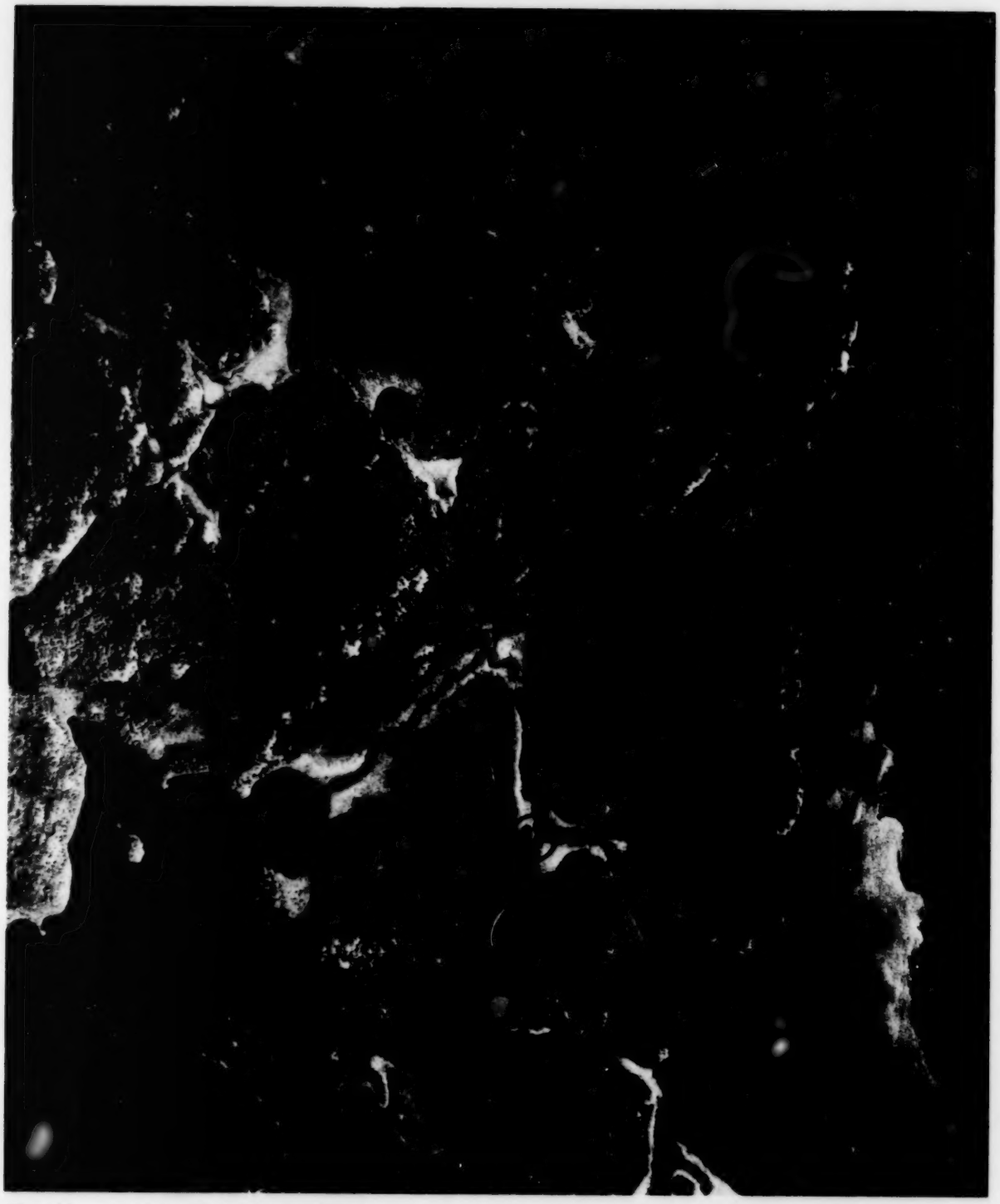


Figure 10. *Aerial view of Selected Sand and Gravel Resource Areas 22, 23 and 24, northwest of Fort Frances, scale 1:15 840.*

Sample Data: Sample FF-SS-5 contained 64 percent gravel, 34 percent sand and 2 percent fines (Figure 21a). This material is well suited for crushing purposes.

General Aggregate Potential: The deposit is likely well suited for the extraction of crusher-run and/or pit-run aggregate products.

Resource Estimates: Area - 19 acres (8 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 19 acres (8 ha)
Average Deposit Thickness - 12 feet (4 m)
Available Aggregate - 570 000 tons (520 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 25

Location: Near the southern shore of Pipestone Lake (Figure 11)

Glacial Origin: Ice-contact

Topography: The feature is associated with a broad, gently sloping till plain which flanks the northwestern side of a prominent bedrock ridge.

Subsurface Data: A test pit revealed 3 feet (1 m) of interbedded fine to medium sand and fine gravel. A 6-inch (15 cm) thick clay seam was also observed in the pit.

General Aggregate Potential: Additional subsurface investigation is recommended to determine if till is present at depth and the amount of clay. Nevertheless, the deposit has potential for the extraction of limited quantities of road-building aggregate.

Resource Estimates: Area - 1.0 acres (0.4 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 1.0 acres (0.4 ha)
Average Deposit Thickness - 12 feet (4 m)
Available Aggregate - 30 000 tons (27 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 26

Location: Near the southern shore of Pipestone Lake (Figure 11)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit consists of a ridge with local relief of 10 feet (3 m).

Subsurface Data: An excavation into the crest of the ridge exposed 3 feet (1 m) of fine to medium gravel. The gravel content of the material was approximately 55 percent and the gravel averaged less than 1 inch (2.5 cm) in size.

General Aggregate Potential: The aggregate appears well suited for pit-run uses.

Resource Estimates: Area - 1.3 acres (0.5 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 1.3 acres (0.5 ha)
Average Deposit Thickness - 10 feet (3 m)
Available Aggregate - 32 500 tons (29 500 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 27

Location: Approximately 1.2 miles (1.9 km) south of Pipestone Lake (Figure 11)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit rises to a maximum of 20 to 35 feet (6 to 11 m) above the valley floor. A prominent bedrock ridge is situated along the deposit's northern boundary.

Subsurface Data: A test pit opened in the southwestern part of the deposit exposed 3 feet (1 m) of fine gravel. Most of the gravel ranged from 0.5 to 0.75 inches (1.2 to 1.9 cm) in size. The gravel content of the material was estimated to be 65 percent. Similar material was encountered elsewhere in the feature.

General Aggregate Potential: The deposit is considered to be an excellent potential source of pit-run aggregate. The probable existence of a variable bedrock surface may restrict the amount of available aggregate in places.

Resource Estimates: Area - 8 acres (3 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 8 acres (3 ha)
Average Deposit Thickness - 15 feet (5 m)
Available Aggregate - 300 000 tons (270 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 28

Location: Approximately 0.3 miles (0.5 km) north of Hoey Lake (Figure 12)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit is fan shaped and flanks the south side of a bedrock ridge.

Subsurface Data: A test pit revealed 3 feet (1 m) of coarse gravel with a coarse sand matrix. The material contained about 60 percent gravel, and abundant cobbles and boulders.

General Aggregate Potential: The deposit contains limited amounts of material in an area in which aggregate resources are scarce. Variable amounts of till may occur within the deposit and oversize clasts may have to be removed for pit-run uses.

Resource Estimates: Area - 0.9 acres (0.4 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 0.9 acres (0.4 ha)
Average Deposit Thickness - 6 feet (2 m)
Available Aggregate - 13 500 tons (12 200 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 29

Location: Approximately 0.8 miles (1.3 km) northwest of Biddison Lake (Figure 13)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit consists of a ridge which rises to a maximum height of 20 feet (6 m) alongside a prominent bedrock knob.

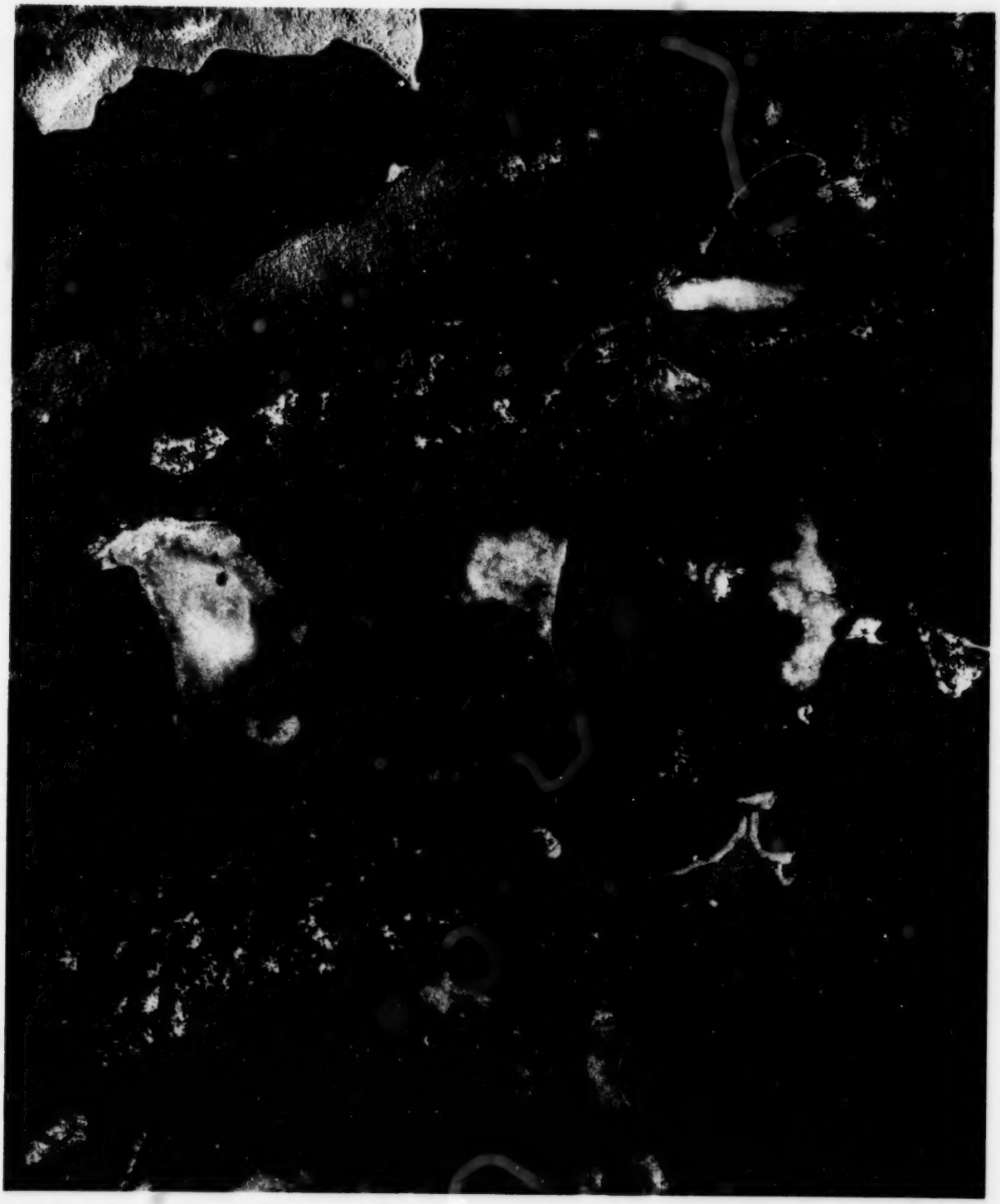


Figure 11. *Aerial view of Selected Sand and Gravel Resource Areas 25, 26 and 27, northwest of Fort Frances, scale 1:15 840.*

Figure 12. *Aerial view of Selected Sand and Gravel Resource Area 28, northwest of Fort Frances, scale 1:15 840.*

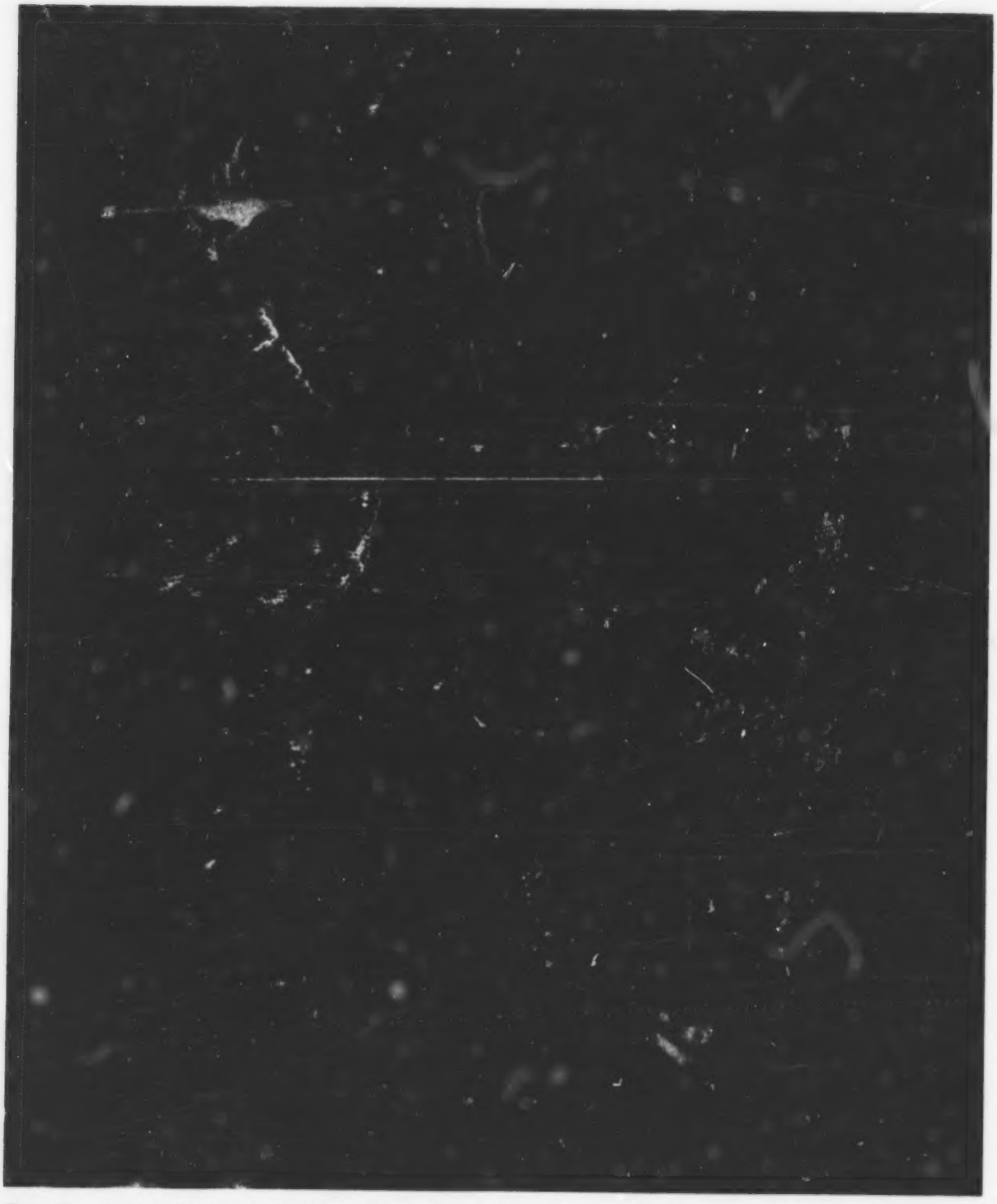


Figure 13. *Aerial view of Selected Sand and Gravel Resource Areas 29, 30 and 31, northwest of Fort Frances, scale 1:15 840.*

Subsurface Data: Excavation into the ridge revealed 3 feet (1 m) of poorly sorted, angular, coarse gravel with a fine sand matrix. The gravel content of the material was estimated to be 60 to 70 percent. Cobbles and boulders were common.

General Aggregate Potential: The deposit is considered suitable for the extraction of limited amounts of road-building aggregate. Factors which may restrict aggregate potential include the presence of abundant oversize clasts and the possible existence of till at depth.

Resource Estimates: Area - 0.8 acres (0.3 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 0.8 acres (0.3 ha)
Average Deposit Thickness - 12 feet (4 m)
Available Aggregate - 24 000 tons (21 800 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 30

Location: Along Biddison Creek south of Biddison Lake (Figure 13)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit attains a maximum height of 30 feet (9 m) along the south side of a bedrock ridge.

Subsurface Data: Two feet (0.6 m) of sandy gravel was underlain by bouldery coarse granular material in a test pit. The upper gravel unit contained approximately 35 to 40 percent coarse material.

General Aggregate Potential: The aggregate is considered to be of variable quality. Till may occur at depth and oversize clasts may have to be removed for pit-run uses.

Resource Estimates: Area - 3.6 acres (1.5 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 3.6 acres (1.5 ha)
Average Deposit Thickness - 15 feet (5 m)
Available Aggregate - 135 000 tons (122 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 31

Location: Approximately 0.2 miles (0.3 km) southeast of Biddison Lake (Figure 13)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit forms a ridge which gently rises in a northerly direction to a height of over 20 feet (6 m). Bedrock outcrops along the northern boundary of the deposit.

Subsurface Data: Sandy fine gravel was observed in a 3-foot (1 m) deep test pit excavated in the ridge at site FF-SS-6.

Sample Data: Sample FF-SS-6 consisted of 38 percent gravel, 60 percent sand and 2 percent fines (Figure 21a). The gravel was too fine for crushing purposes.

General Aggregate Potential: The deposit is considered to be an excellent potential source of pit-run material.

Resource Estimates: Area - 6 acres (2 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 6 acres (2 ha)
Average Deposit Thickness - 15 feet (5 m)
Available Aggregate - 225 000 tons (204 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 32

Location: Approximately 0.5 miles (0.8 km) east of Whidden Lake (Figure 14)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit forms a ridge which rises steeply from the valley floor to a height of 10 to 20 feet (3 to 6 m). The feature was deposited against a bedrock knob which is exposed along the deposit's eastern boundary.

Subsurface Data: Two test pits were excavated in the ridge. The test pit opened in the northern part of the deposit revealed 2 feet (0.6 m) of fine gravelly sand over 1.5 feet (0.4 m) of silty very fine sand. The other test pit uncovered 3 feet (1 m) of sandy fine gravel in the southern tip of the feature. This material contained an estimated 35 to 40 percent gravel.

General Aggregate Potential: The deposit exhibits good potential as a source of pit-run aggregate. Silty, very fine sand units may have to be avoided during extraction.

Resource Estimates: Area - 2.0 acres (0.8 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 2.0 acres (0.8 ha)
Average Deposit Thickness - 15 feet (5 m)
Available Aggregate - 75 000 tons (68 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 33

Location: Between Whidden Lake and Ash Bay of Rainy Lake (Figure 14)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit consists of an 8-foot (2 m) high ridge which flanks bedrock.

Subsurface Data: A test pit uncovered 3 feet (1 m) of sandy material containing 25 percent fine gravel.

General Aggregate Potential: The deposit appears suitable for the extraction of limited quantities of pit-run aggregate.

Resource Estimates: Area - 0.8 acres (0.3 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 0.8 acres (0.3 ha)
Average Deposit Thickness- 8 feet (2 m)
Available Aggregate - 16 000 tons (14 500 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 34

Location: Approximately 1.2 miles (1.9 km) northeast of Spencer Lake (Figure 15)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit fills a depression on the south side of a very prominent bedrock ridge. Boulders are common on the surface of the deposit.

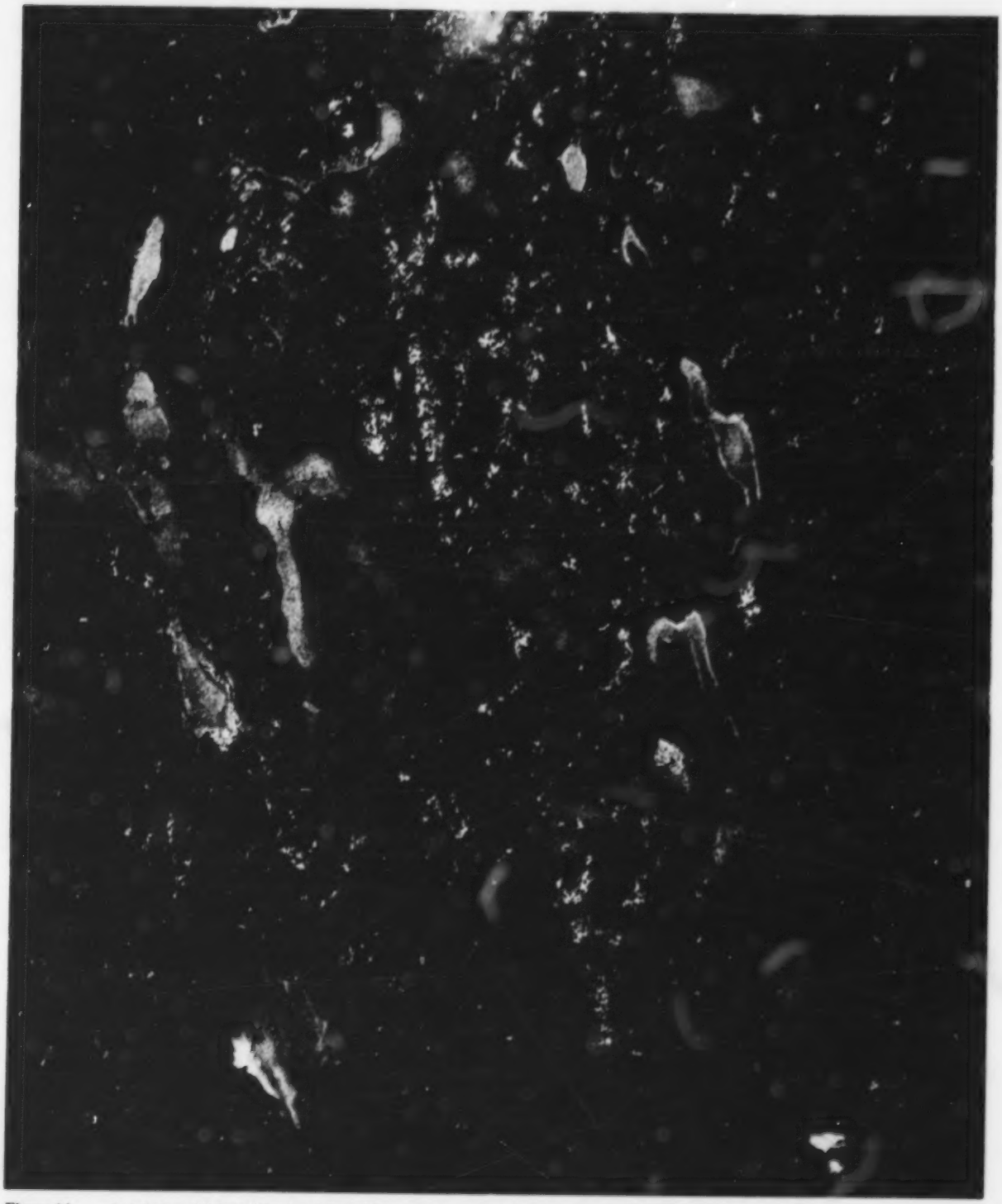


Figure 14. *Aerial view of Selected Sand and Gravel Resource Areas 32 and 33, northwest of Fort Frances, scale 1:15 840.*

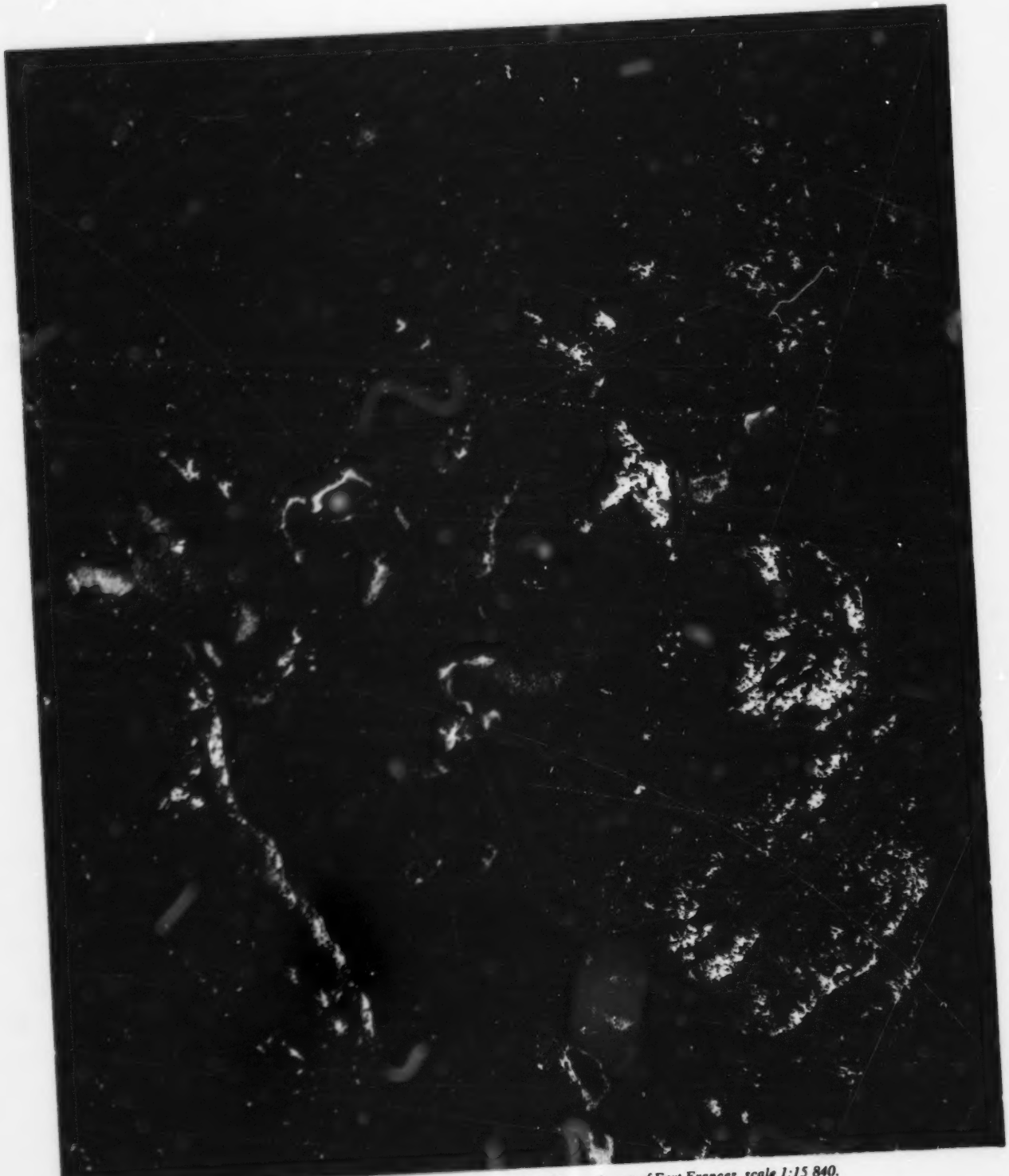


Figure 15. *Aerial view of Selected Sand and Gravel Resource Areas 34 to 39, northwest of Fort Frances, scale 1:15 840.*

Subsurface Data: A 3-foot (1 m) deep test pit exposed 1 foot (0.3 m) of bouldery, very coarse gravel over 2 feet (0.6 m) of sandy, fine to medium gravel. The lower 2-foot (0.6 m) unit contained approximately 45 to 50 percent coarse material.

General Aggregate Potential: The deposit is potentially a source of at least pit-run aggregate. Oversize clasts may have to be removed for pit-run uses.

Resource Estimates: Area - 6 acres (2 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 6 acres (2 ha)
Average Deposit Thickness - 15 feet (5 m)
Available Aggregate - 225 000 tons (204 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 35

Location: Approximately 0.9 miles (1.4 km) northeast of Spencer Lake (Figure 15)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit flanks a bedrock ridge and is estimated to be about 8 feet (2 m) thick.

Subsurface Data: A test pit exposed 3 feet (1 m) of coarse gravel containing 65 to 70 percent coarse material ranging in size from 3 to 6 inches (8 to 15 cm).

General Aggregate Potential: The deposit is suitable for the production of limited amounts of crushed gravel. Oversize clasts should be removed or processed.

Resource Estimates: Area - 1.0 acres (0.4 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 1.0 acres (0.4 ha)
Average Deposit Thickness - 8 feet (2 m)
Available Aggregate - 20 000 tons (18 100 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 36

Location: Approximately 0.9 miles (1.4 km) northeast of Spencer Lake (Figure 15)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit rises from the valley floor to a maximum height of 20 feet (6 m) alongside a prominent bedrock ridge.

Subsurface Data: Test pits revealed 2 feet (0.6 m) of clean, sandy fine to medium gravel. The gravel content of this material ranged from 45 to 50 percent. This upper gravel unit was underlain by at least 1 foot (0.3 m) of coarse gravel and boulders.

General Aggregate Potential: Although the deposit demonstrates good potential as an aggregate source, additional subsurface investigation is required prior to extraction. Variable amounts of till may occur at depth and oversize clasts should be removed or processed.

Resource Estimates: Area - 2.1 acres (0.8 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 2.1 acres (0.8 ha)
Average Deposit Thickness - 15 feet (5 m)
Available Aggregate - 79 000 tons (72 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 37

Location: Approximately 0.4 miles (0.6 km) northeast of Spencer Lake (Figure 15)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit forms a gently sloping ridge which rises an average of 10 feet (3 m) above the valley floor. A prominent bedrock knob outcrops along the eastern border of the feature.

Subsurface Data: A test pit revealed 2.5 feet (0.8 m) of bouldery, coarse gravel with a medium to coarse sand matrix. The gravel content of the material was estimated to be 70 percent.

General Aggregate Potential: The material appears well suited for crushing. Oversize material may have to be removed for pit-run uses.

Resource Estimates: Area - 0.8 acres (0.3 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 0.8 acres (0.3 ha)
Average Deposit Thickness - 10 feet (3 m)
Available Aggregate - 20 000 tons (18 100 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 38

Location: Approximately 1.2 miles (1.9 km) north of Spencer Lake (Figure 15)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit consists of a fan-shaped ridge which rises steeply from the valley floor (swamp) to an average height of 20 feet (6 m). The material flanks a bedrock ridge which is exposed along the northern boundary of the feature.

Subsurface Data: Excavation of a test pit uncovered 1 foot (0.3 m) of bouldery, coarse gravel over 2 feet (0.6 m) of sandy gravel. The lower sandy gravel unit contained between 40 and 45 percent gravel which had a maximum grain size of 1.5 inches (3.8 cm).

General Aggregate Potential: The deposit appears to be a good potential source of pit-run aggregate. Oversize clasts may have to be removed, however, for pit-run uses.

Resource Estimates: Area - 2.4 acres (1.0 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 2.4 acres (1.0 ha)
Average Deposit Thickness - 20 feet (6 m)
Available Aggregate - 120 000 tons (109 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 39

Location: Approximately 0.4 miles (0.6 km) north of Spencer Lake (Figure 15)

Glacial Origin: Lee side ice-contact feature

Topography: The deposit rises to a maximum height of 30 feet (9 m) above the valley floor. The aggregate flanks a bedrock ridge which trends in a northwest direction.

Subsurface Data: Two feet (0.6 m) of bouldery, very coarse gravel was underlain by at least 1 foot (0.3 m) of fine to medium gravel in a test pit excavated into the feature. The gravel content of the material ranged from 60 to 70 percent.

General Aggregate Potential: The aggregate is likely well suited for crushing purposes. Oversize clasts require removal or processing for pit-run uses. Till may be encountered at depth in the feature.

Resource Estimates: Area - 4.8 acres (1.9 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 4.8 acres (1.9 ha)
Average Deposit Thickness - 15 feet (5 m)
Available Aggregate - 180 000 tons (163 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 40

Location: Consists of four deposits situated along and near Mile River between Lake Despair and Footprint Lake (Figure 16)

Glacial Origin: Ice-contact

Topography: The features are flat lying, valley fill deposits.

Subsurface Data: Exposures along the bank of Mile River, in three of the four deposits, revealed 5 feet (1.5 m) of sandy material with 20 to 40 percent fine gravel.

General Aggregate Potential: The deposits are considered to be excellent potential sources of pit-run aggregate. Little subsurface information is available for the northernmost deposit. This feature, however, was deposited in a similar geological environment as the other three features and is expected to have a similar resource potential.

Resource Estimates: Area - 128 acres (52 ha)
Cultural Setbacks - 38 acres (15 ha)
Extracted Area - none
Available Area - 90 acres (36 ha)
Average Deposit Thickness - 6 feet (2 m)
Available Aggregate - 1 million tons (1 million tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 41

Location: Near Lake Despair at Monument Point (Figure 16)

Glacial Origin: Ice-contact

Topography: The deposit forms a prominent ridge which rises to a maximum height of 30 feet (9 m) above the surrounding terrain. The northern slopes of the ridge are very steep and the southern slopes are gentle.

Subsurface Data: A test pit excavated into the ridge at site FF-SS-7 exposed very clean, angular, coarse sand with minor amounts of very fine gravel. Similar material was encountered by soil augering elsewhere along the ridge.

Sample Data: Sample FF-SS-7 contained 1 percent gravel, 97 percent sand and 2 percent fines (Figure 22a). The material met MTO specifications for use as Granular Base Course (GBC) B.

General Aggregate Potential: The feature is considered an excellent potential source of sand suitable for road subbase applications.

Resource Estimates: Area - 12 acres (5 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 12 acres (5 ha)
Average Deposit Thickness - 25 feet (8 m)
Available Aggregate - 750 000 tons (680 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 42

Location: Approximately 0.6 miles (1.0 km) north of Manomin River along a winter road (Figure 17)

Glacial Origin: Moraine

Topography: The feature forms a prominent ridge which exhibits local relief in excess of 50 feet (15 m).

Subsurface Data: A test pit excavated into the crest of the ridge exposed 3 feet (1 m) of medium gravel with a clean, medium to coarse sand matrix. The material contained approximately 65 percent gravel of which the majority was between 1 and 3 inches (2 and 8 cm) in size.

General Aggregate Potential: The deposit is considered to be an excellent potential source of pit-run and crusher-run aggregates.

Resource Estimates: Area - 6 acres (2 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 6 acres (2 ha)
Average Deposit Thickness - 35 feet (11 m)
Available Aggregate - 520 000 tons (470 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 43

Location: Approximately 0.6 miles (1.0 km) north of the Manomin River (Figure 17)

Glacial Origin: Moraine

Topography: Steep slopes in excess of 30 feet (9 m) high mark the southern boundary of the feature. North of these slopes the deposit is relatively flat with the exception of a 5-foot (1.5 m) high ridge situated in the northern corner of the deposit. Bedrock is exposed along the eastern, western and northern boundaries of the feature.

Subsurface Data: Two test pits were excavated in the deposit. Four feet (1.2 m) of gravelly medium to coarse sand was uncovered in the test pit excavated in the central part of the feature at site FF-SS-9. The other test pit was opened along the western border of the feature at site FF-SS-8. It revealed 2.5 feet (0.8 m) of sandy gravel with between 35 and 45 percent gravel.

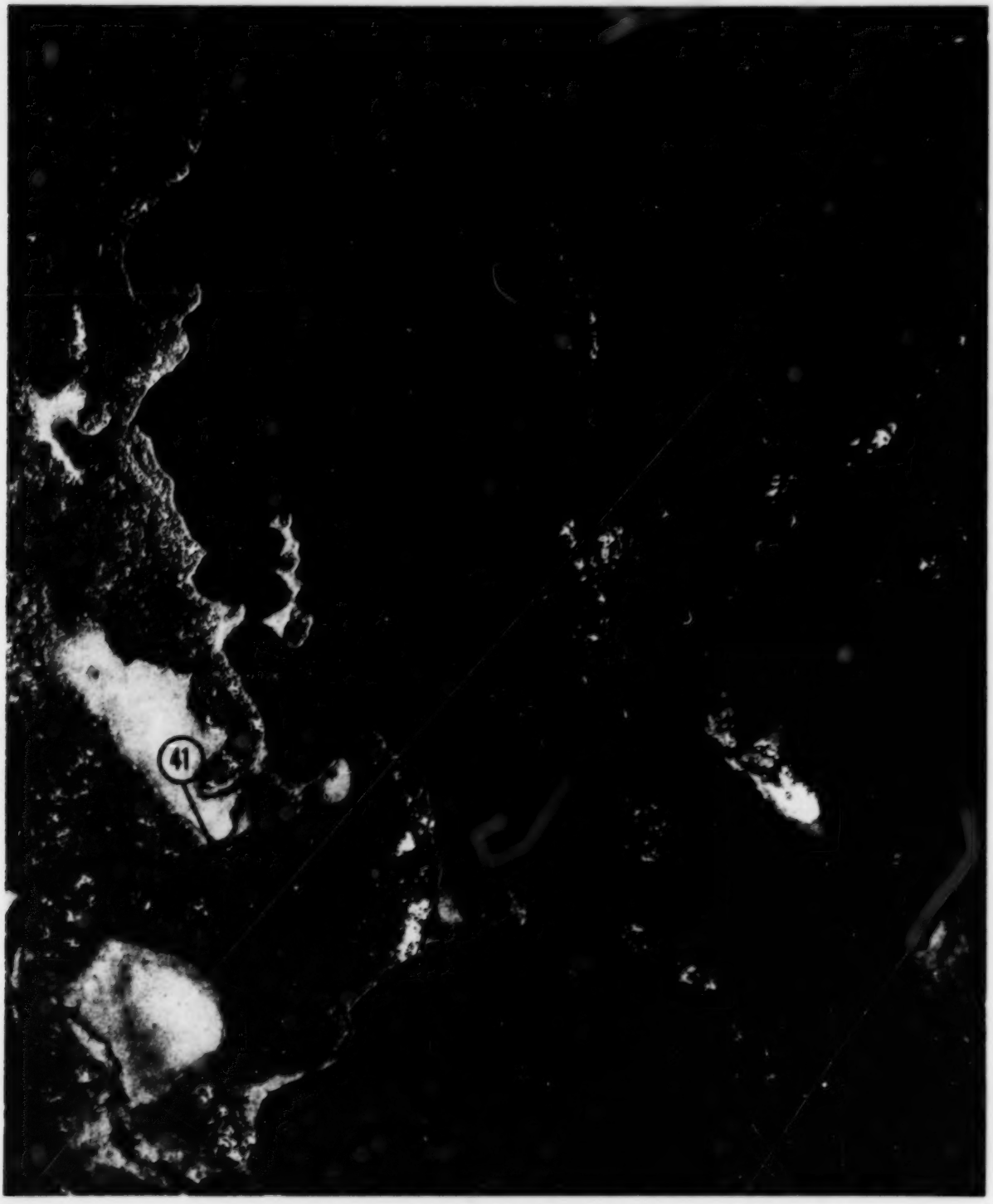


Figure 16. *Aerial view of Selected Sand and Gravel Resource Areas 40 and 41, northwest of Fort Frances, scale 1:15 840.*

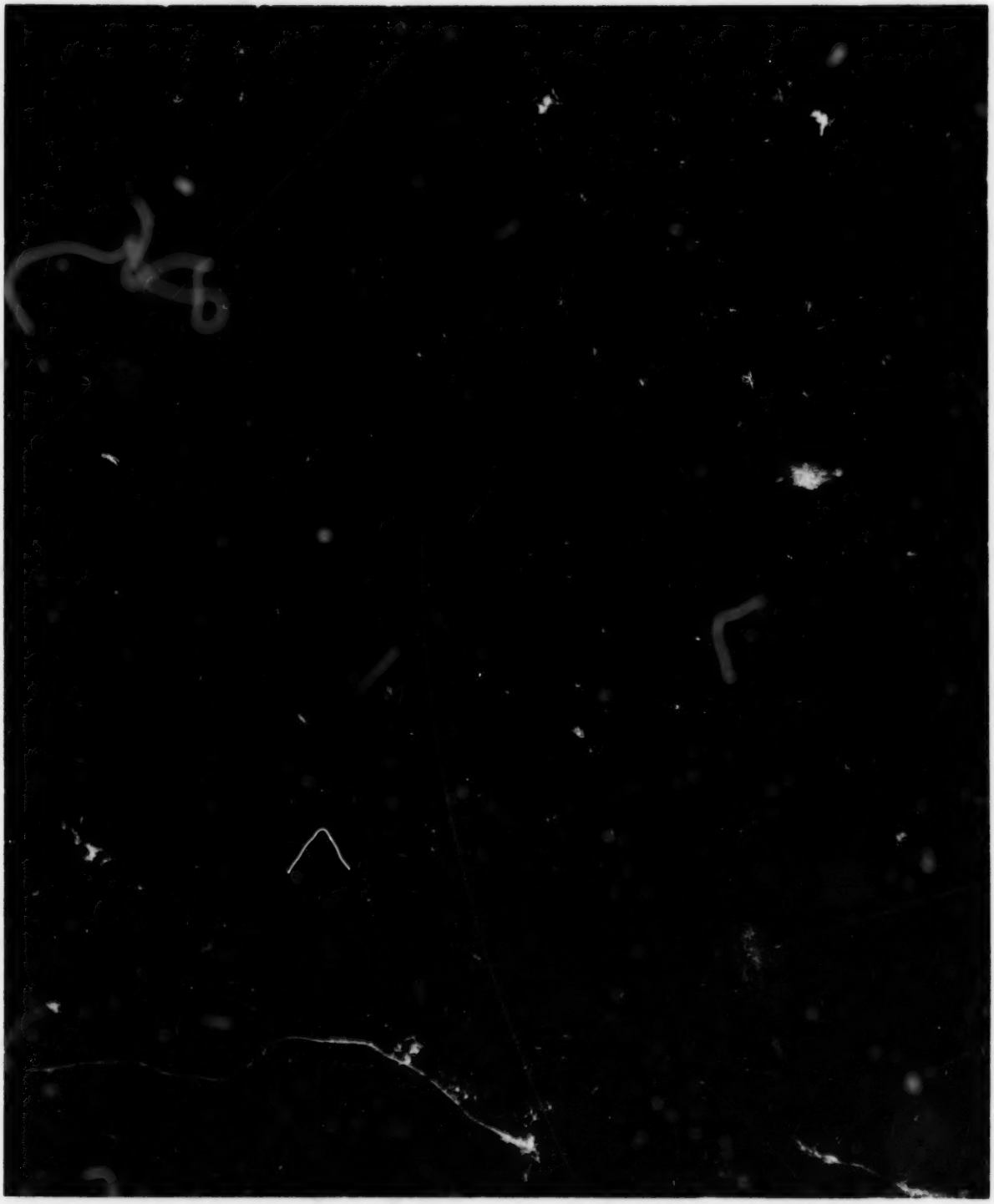


Figure 17. *Aerial view of Selected Sand and Gravel Resource Areas 42 and 43, northwest of Fort Frances, scale 1:15 840.*

Sample Data: Sample FF-SS-9 contained 15 percent gravel, 78 percent sand and 7 percent fines (Figure 22a). Coarser aggregate was revealed in sample FF-SS-8 which contained 44 percent gravel, 53 percent sand and 3 percent fines (Figure 22a). Both samples met MTO specifications for GBC B. The gravel in sample FF-SS-8 was hard and durable as indicated by the analyses in Table 3.

General Aggregate Potential: The deposit is considered an excellent potential source of pit-run aggregate.

Resource Estimates: Area - 12 acres (5 ha)
Cultural Setbacks - none
Extracted Area - none
Available Area - 12 acres (5 ha)
Average Deposit Thickness - 15 feet (5 m)
Available Aggregate - 450 000 tons (410 000 tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 44

Location: Approximately 3.1 miles (5.0 km) west of Secondary Highway 613 along a forest access road that parallels Christie Creek (Figure 18)

Glacial Origin: Moraine

Topography: The terrain is variable, ranging from flat lying to hummocky.

Subsurface Data: Two pits have been developed in the deposit. Faces in pit no. 8 ranged from 10 to 20 feet (3 to 6 m) high and exposed sandy gravel. Silt and clay sections should be avoided in the pit. Selection and sand control would be required for crushing. The faces in pit no. 9 revealed 4 feet (1.2 m) of sandy fine gravel over clean medium sand. The gravel content of the material ranged from 20 to 40 percent.

General Aggregate Potential: The material exposed in the pits appears well suited for the extraction of a variety of aggregate products. Elsewhere in the deposit, however, the aggregate potential may be extremely variable. Till pockets, clay layers and bedrock outcrop may be locally abundant.

Resource Estimates: Area - 840 acres (340 ha)
Cultural Setbacks - 39 acres (16 ha)
Extracted Area - 1.0 acres (0.4 ha)
Available Area - 800 acres (325 ha)
Average Deposit Thickness - 15 feet (5 m)
Available Aggregate - 30 million tons (27 million tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 45

Location: Approximately 1.2 miles (1.9 km) west of Secondary Highway 613 along a forest access road that parallels Christie Creek (Figure 18)

Glacial Origin: Moraine

Topography: The terrain is variable, ranging from flat lying to hummocky.

Subsurface Data: Faces in pit no. 10 ranged from 10 to 25 feet (3 to 8 m) high and exposed aggregate of varying quality. The material generally ranged from very coarse gravel with abundant boulders to clean, medium to coarse sand. In some sections of the pit, silt and clay units up to 6 feet (2 m) thick overlay the aggregate. Pockets of silty fine sand were also common in some faces. The gravel content of the material in the pit ranged from 0 to 70 percent.

Sample Data: Two samples were taken from a 10-foot (3 m) high face in the southern part of pit no. 10. The face consisted of 6 feet (2 m) of fine to medium sand over sandy fine to medium gravel. A sample taken from the sand unit contained 85 percent sand and 15 percent fines (Figure 19a, Pit 10a). This material appears best suited for use as fill. The gravel unit contained 51 percent gravel, 48 percent sand and 1 percent fines (Figure 19a, Pit 10b) and this material is acceptable for crushing. Selective extraction and sand control, however, would probably be required for crushing.

General Aggregate Potential: The pit revealed aggregate of varying quality. Products that may be produced from the pit range from fill to crushed gravel. Till pockets, clay layers and bedrock outcrop may occur locally within the deposit.

Resource Estimates: Area - 430 acres (174 ha)
Cultural Setbacks - 9 acres (4 ha)
Extracted Area - 6 acres (2 ha)
Available Area - 415 acres (168 ha)
Average Deposit Thickness - 15 feet (5 m)
Available Aggregate - 16 million tons (14 million tonnes)

SELECTED SAND AND GRAVEL RESOURCE AREA 46

Location: Alongside Secondary Highway 613 (Figure 18)

Glacial Origin: Moraine

Topography: The terrain is variable, ranging from flat lying to hummocky.

Subsurface Data: Ten to twenty feet (3 to 6 m) of material of variable quality was exposed in pit no. 11. The material ranges from bouldery, coarse gravel to pockets of silty, fine sand. Large boulders up to 5 feet (1.5 m) in diameter are common in the pit. In some sections, the gravel is coated with a thin film of fines and silt layers occur in the floor of the western part of the pit. The amount of gravel in the pit was estimated to range from 50 to 70 percent.

General Aggregate Potential: A variety of aggregate products ranging from fill to crushed gravel may be produced from the pit with selective extraction. Similar quality material may be available from the undeveloped parts of the deposit. In these undeveloped areas, however, till pockets, silt and clay layers, and bedrock outcrops may be locally abundant.

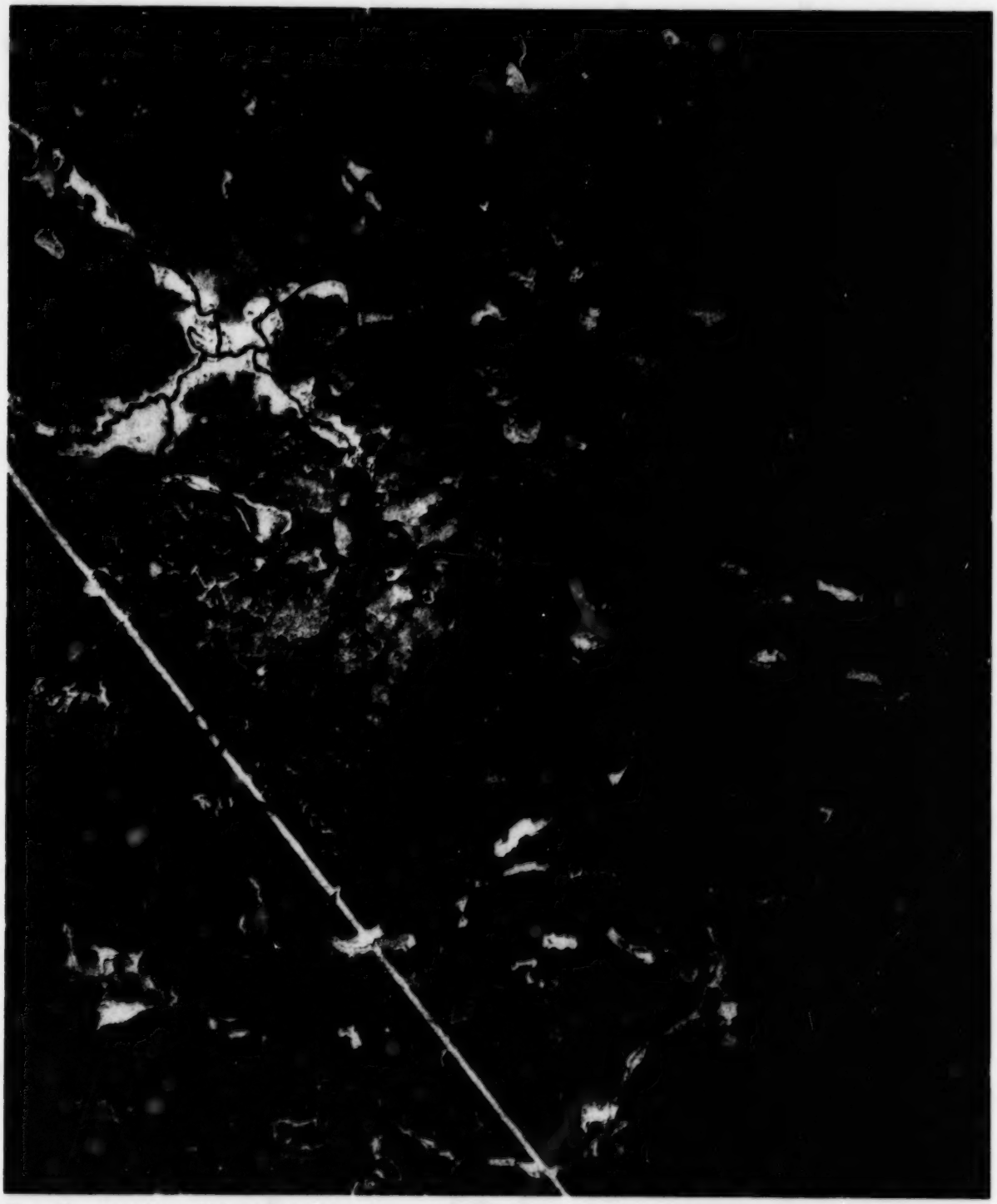


Figure 18. *Aerial view of Selected Sand and Gravel Resource Areas 44, 45 and 46, northwest of Fort Frances, scale 1:63 360.*

Resource Estimates: Area - 40 acres (16 ha)
Cultural Setbacks - 5 acres (2 ha)
Extracted Area - 5 acres (2 ha)
Available Area - 30 acres (12 ha)
Average Deposit Thickness - 15 feet (5 m)
Available Aggregate - 1 million tons (1 million tonnes)

RESOURCES OF GRANULAR FILL

For the most part, the report area contains abundant resources of fill suitable for road subgrade construction. The most widespread potential source of fill in the area is till. Till occurs under thick tree cover throughout the area. The average composition of till in the general Lake of the Woods area may vary from about 35 percent gravel, 49 percent sand and 15 percent silt and clay (Minning 1988) to 22 percent gravel, 54 percent sand and 23 percent silt and clay (Cowan 1987). The till generally occurs as a thin veneer over bedrock, typically less than 5 feet (1.5 m) thick. The exceptions are those till deposits outlined on Map 1 which may contain material in excess of 5 feet (1.5 m) in thickness.

The till deposits portrayed on Map 1 usually flank bedrock ridges and knobs in a similar manner as the lee side ice-contact features. Those deposits delineated by a solid line on the map are known sources of till. A dashed line around till deposits indicates potential deposits delineated through aerial photograph interpretation. These interpreted deposits should be considered at least potential sources of fill. Although they are expected to contain till, based on examining similar deposits in the field, variable quantities of sand and gravel may also occur. Till resources may be especially valuable in areas where sand and gravel resources are lacking.

Terrain in which fill resources are scarce is dominated by bare bedrock and swamp. Fill may have to be imported into these deficient areas for road-building purposes. The terrain between Manitou Sound of Rainy Lake and Ash Lake contains extremely limited fill resources. Similarly, fill resources are lacking in the vicinity of Smoulder and Hutchins lakes.

BEDROCK GEOLOGY AND RESOURCE POTENTIAL

The project area lies within the southwestern part of the Superior Province of the Canadian Shield. Most of the area is underlain by granitic rocks (Blackburn 1981). The exception is a belt of predominantly metavolcanic rocks which extends from Burditt Lake to Furlonge Lake along the western and northern boundaries of the study area.

In general, the bedrock is hard and resistant to weathering, and is considered a potential source of aggregate. It is unlikely, however, that bedrock-derived aggregate will be used for access road development because of the higher costs involved in quarrying. For this reason, the bedrock geology and resource potential has not been described in detail in this report. Detailed information on the bedrock of this area is available in reports and maps by Davies (1973), Blackburn (1976, 1981) and Edwards (1983a, 1983b).

AGGREGATE QUALITY AND SUITABILITY

During the field investigation, 13 samples were taken from existing pit faces and test pits. The samples were analyzed for grain size distribution (Figures 19a to 22b) and two aggregate quality tests were performed on selected samples. These tests were the Los Angeles abrasion and impact test, and petrographic analysis. The results of these tests are portrayed in Table 3. The two quality tests were performed in the laboratories of the Ontario Ministry of Transportation, Northwestern Region. Grain size analyses were conducted in either the Ministry of Transportation Laboratory or in the Geoscience Laboratory, Ontario Geological Survey.

In general, the sand and gravel deposits in the study area are of sufficient quality to meet most access road demands. The results of the two quality tests performed on the gravel component of the aggregate indicate the gravel is hard and durable. These results fall within MTO specifications for most hot-laid asphalt products, 16 mm crushed stone and granular base course. MTO records for pits developed in the southern part of the report area indicate the aggregate is acceptable for a range of products including 16 mm crushed stone and granular base course. Grain size analysis of selected samples indicates the material is generally suitable for a variety of aggregate products. The presence of high quality sand and gravel in most deposits is supported by field observations.

Factors which may limit aggregate suitability, if encountered, include excessive quantities of fines and/or oversize clasts. Silt and clay layers occur within a number of the deposits. For the most part, these layers are local occurrences and may be avoided through selective extraction measures. Oversize clasts are abundant in several deposits. This oversize material would have to be removed or processed for most aggregate uses.

RECOMMENDATIONS FOR ACCESS ROAD DEVELOPMENT AND FUTURE AGGREGATE EXPLORATION

Two general road corridors are proposed for the report area. These corridors will probably consist of at least two main road arteries with several smaller logging roads and trails branching off these arteries. One corridor (southeast road corridor) is proposed to access forest stands located south and east of Kaiashkons, Loonhaunt, Jackfish and Footprint lakes. The other corridor (northwest road corridor) is proposed to access timber north and west of Furlonge, Kaiashkons, Loonhaunt, Biddison, West Jackfish, Ottertail and Albert lakes. At present, the exact locations of the access roads within these corridors have not been finalized. The results of

this aggregate assessment should provide valuable information needed for the advanced planning and development of these access roads.

Several factors may influence planning the route of a forest access road. Since the roads are designed primarily to access timber, the proximity to prime forest stands is an important concern. The terrain is also a major consideration. Preferred terrain would be flat, well drained and have an acceptable bearing capacity. The cost of road construction may increase substantially when the road is located in rugged bedrock in which blasting is required (Ontario Ministry of Natural Resources 1988; Roed 1980a, 1980b). Steep slopes and cliffs should also be avoided. Organic terrain (swamp) is also a major constraint. Swamp typically has a low bearing capacity, is poorly drained and is susceptible to frost action. Higher costs are also associated with bridge and culvert construction. For this reason, access roads are often planned to cross as few watercourses as possible. Access roads within the study area may also be designed to avoid close contact with major lakes to retain the lakes' natural environment and tourism potential. Various engineering, environmental and other factors may also impact access road design and development.

Another important planning concern is the proximity of the road to sources of aggregate. Sand and gravel is required for the development of the upper surface (surfacing and subbase) of the access road. A typical primary access road (2 lanes) in northwestern Ontario consists of an upper 6-inch (15 cm) layer of gravel underlain by 1 foot (30 cm) of subbase material (GBC C). A secondary access road (one-and-a-half lanes) generally requires a 6-inch (15 cm) upper surface of sand and gravel. In addition, fill materials are required for construction of the roadbed foundation (subgrade). Readily available materials along the route of the access road are usually graded to form the foundation. These materials include till, silt, clay, sand, gravel and rock. Because the transportation of aggregates is a major factor in determining aggregate cost, it is preferable to plan roads as close as possible to potential aggregate deposits. Once the roads are built, sand and gravel may also be required for road maintenance purposes.

The southeast road corridor contains relatively abundant potential resources of sand and gravel. Twenty-seven Resource Areas have been selected along the corridor. The route considered to best use the potential aggregate resources (ignoring other planning considerations) would proceed in close proximity to Selected Sand and Gravel Resource Areas 4, 5, 9, 12, 13, 14 and 20 and parts of Areas 32 to 39. The longest distance between Resource Areas along this suggested route would be approximately 5.5 miles (9 km). Considerable resources may also be available by accessing selected sand and gravel resources outside this route, especially Resource Area 8.

Aggregate resources are relatively scarce along the northwest road corridor. Twelve deposits have been selected in this area, of which eight deposits potentially contain over 100 000 tons (91 000 tonnes) of sand and gravel. The eight deposits include Selected Sand and Gravel Resource Areas 1, 2, 7, 27, 30, 31, 42 and 43. Because of terrain considerations, Areas 1, 7, 27, 42 and 43 may prove to be the most readily accessible of these deposits. Resources from the remaining three Areas may prove valuable, however, if access is developed off the main road arteries. Along this corridor, the general area between Resource Areas 27 and 42 contains only extremely limited potential aggregate resources.

In areas of limited aggregate resources, till deposits may provide alternative sites for pit development. Several deposits have been identified which contain significant thicknesses of till. Of these deposits, several have been delineated by aerial photograph interpretation. Because of the interpretative nature of these deposits, it is recommended that the locations of proposed roads are not altered to intersect these deposits without ground checking the materials first. The potential till deposits located between Feather Lake and Benninger Lake are examples of interpretative deposits which are well situated within a sand and gravel deficient section of the proposed road corridor.

During field investigation, most areas exhibiting high potential for aggregate extraction were accessed. It was not possible to visit all potential deposits, especially those which were interpreted as having low potential for extraction. Consequently, additional resources may be discovered during road construction and logging in the area. As an aid to future aggregate exploration in the report area and in similar areas within northwestern Ontario, deposit characteristics which may help in the identification of exploration targets are described in the following paragraphs.

Sand and gravel deposits within the report area typically occur under very thick tree cover, unless the area has recently been logged. Thick till deposits, however, may also exist under similar cover. The most common tree type on the sand and gravel deposits is birch. Stands of jackpine and poplar may also be indicative of certain sand and gravel deposits, but these stands may also be common on other terrain types. For example, poplars are usually indicative of till, but they may be abundant on deposits having an upper layer of densely packed, coarse gravel.

Topographic and geologic criteria are also important in helping to identify potential resources. Lee side ice-contact features tend to occur as isolated, widely scattered features. They form fan-shaped or kame-like ridges on the southern and southwestern sides of prominent bedrock ridges. Concentrating exploration and/or access road development along these ridges should lead to a higher probability of discovering this type of sand and gravel deposit. Adequate resources of till for road subgrade construction are also likely to be encountered in these lee side areas.

Moraines occur as prominent northwest-trending ridges. Moraine ridges usually do not flank bedrock as is characteristic of lee side ice-contact features. Moraines often occur in belts perpendicular to the direction of ice

flow. Therefore, if one moraine segment is identified, others can often be discovered by checking potential areas to the northwest and southeast of known deposits. Resource Areas 2, 4, 5 and 6, 42 and 43, and 44 to 46 form morainic belts.

Sand and gravel deposits which trend north or northeast (parallel to the direction of ice flow) within bedrock controlled valleys in the report area are usually eskers or undifferentiated ice-contact features. Eskers form prominent ridges which are often flanked by kettle depressions. The ice-contact features can be hummocky or flat lying. Exploration of glacial materials under thick tree cover within bedrock controlled valleys orientated parallel to the ice-flow direction may lead to the discovery of these deposit types. Once one deposit is discovered in a bedrock controlled valley, others can often be identified by following similar bedrock controlled valleys away from the known deposit. The deposits which constitute Resource Areas 12, 13, 14, 17, 20, 22, 23 and 24 were discovered using this technique.

SUMMARY

The sand, gravel and till deposits in the report area are the product of glacial activity which occurred during the Late Wisconsinan Substage of the Pleistocene Epoch. The deposits which contain the most significant resources of sand and gravel have been grouped together into 46 Selected Sand and Gravel Resource Areas. Most of these areas consist of moraine, esker, kame and other ice-contact features. In addition, numerous till deposits have been identified as potential fill sources. The resource areas and till deposits should provide valuable granular resources for future access road development.

The sand and gravel in the area is generally hard and durable, and suitable for most road-building applications. The deposits contain material which varies from sand, suitable for pit-run uses, to coarse crushable gravel. Oversize clasts are abundant in some of the gravel deposits and this material may need to be removed or processed for aggregate. Minor amounts of fines also occur which may necessitate selective extraction. The Precambrian age bedrock in the area is also a potential source of hard and durable aggregate. The higher costs associated with extraction of bedrock-derived aggregate as compared to glacial materials would, however, inhibit quarry development for access road construction.

Despite a general lack of known sand and gravel deposits in the area, sufficient resources were discovered to help alleviate potential aggregate shortages during future forest access road construction, and to reduce long haulage distances. The exception is an area located north and west of Ottertail and West Jackfish lakes in which aggregate resources are extremely limited.

Enquiries regarding the Aggregate Resources Inventory of Northwest of Fort Frances should be directed to the Aggregate Assessment Office, Engineering and Terrain Geology Section, Ontario Geological Survey, Room M1B-45, Macdonald Block, Queen's Park, 900 Bay Street, Toronto, M7A 1W4, [Tel: (416) 965-1663], or to the Resident Geologist, Kenora District, Box 5050, 808 Robertson Street, Kenora, P9N 3X9, [Tel: (807) 468-3658], or to the Fort Frances District, Ministry of Natural Resources, 922 Scott Street, Fort Frances, P9A 1J4, [Tel: (807) 274-5337].

TABLE 1. SAND AND GRAVEL PITS, NORTHWEST OF FORT FRANCES.

NO.	MTO NO.	FACE HEIGHT Feet (Metres)	% GRAVEL	REMARKS
1	–	10–15 (3–5)	< 40	gravelly sand
2	–	10–20 (3–6)	40–60	fine to medium gravel
3	–	10–20 (3–6)	40–60	limited amounts of aggregate remain
4	–	30–40 (9–12)	–	coarse gravel depleted to bedrock
5	–	45 (14)	50–60	fine to medium gravel
6	N18–35	15–25 (5–8)	–	coarse gravel, near depletion
7	N18–34	10–25 (3–8)	60	variable material ranging from coarse gravel with abundant oversize material to till; silt seams common, near depletion
8	N18–38	10–20 (3–6)	20–50	
9	–	< 5 (< 1.5)	20–40	slumped faces, sandy fine gravel over medium sand
10	N18–40	10–25 (3–8)	0–70	variable material ranging from silty fine sand to coarse gravel; silt and clay pockets, oversize clasts abundant in sections
11	–	10–20 (3–6)	50–70	variable material ranging from pockets of silty fine sand to coarse gravel with abundant oversize clasts; silt seams

TABLE 2. SELECTED SAND AND GRAVEL RESOURCE AREAS, NORTHWEST OF FORT FRANCES.

1 DEPOSIT NO.	2 AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE AGGREGATE Tons (Tonnes)
1	26 (10)	2.0 (0.8)	6 (2)	18 (7)	12 (4)	540 000 (490 000)
2	17 (7)	0 (0)	0 (0)	17 (7)	25 (8)	1 million (1 million)
3	8 (3)	0 (0)	0 (0)	8 (7)	15 (5)	300 000 (270 000)
4	9 (4)	0 (0)	0 (0)	9 (4)	15 (5)	340 000 (310 000)
5	39 (16)	0 (0)	0 (0)	39 (16)	8 (2)	780 000 (710 000)
6	12 (5)	0 (0)	3.0 (1.2)	9 (4)	40 (12)	900 000 (820 000)
7	9 (4)	0 (0)	0 (0)	9 (4)	20 (6)	450 000 (410 000)
8	44 (18)	0 (0)	0 (0)	44 (18)	25 (8)	3 million (3 million)
9	4.0 (1.6)	0 (0)	0 (0)	4.0 (1.6)	15 (5)	150 000 (136 000)
10	1.0 (0.4)	0 (0)	0 (0)	1.0 (0.4)	15 (5)	37 500 (34 000)
11	1.7 (0.7)	0 (0)	0 (0)	1.7 (0.7)	6 (2)	25 500 (23 100)
12	38 (15)	0 (0)	0 (0)	38 (15)	12 (4)	1 million (1 million)
13	1.2 (0.5)	0 (0)	0 (0)	1.2 (0.5)	15 (5)	45 000 (41 000)
14	7 (3)	0 (0)	0 (0)	7 (3)	30 (9)	520 000 (470 000)
15	0.6 (0.2)	0 (0)	0 (0)	0.6 (0.2)	12 (4)	18 000 (16 300)
16	1.5 (0.6)	0 (0)	0 (0)	1.5 (0.6)	10 (3)	37 500 (34 000)
17	9 (4)	0 (0)	0 (0)	9 (4)	15 (5)	340 000 (310 000)
18	4.6 (1.9)	0 (0)	0 (0)	4.6 (1.9)	20 (6)	230 000 (209 000)
19	1.0 (0.4)	0 (0)	0 (0)	1.0 (0.4)	8 (2)	20 000 (18 100)
20	35 (14)	0 (0)	0 (0)	35 (14)	20 (6)	2 million (2 million)
21	1.2 (0.5)	0 (0)	0 (0)	1.2 (0.5)	15 (5)	45 000 (41 000)
22	11 (4)	0 (0)	0 (0)	11 (4)	8 (2)	220 000 (200 000)
23	1.2 (0.5)	0 (0)	0 (0)	1.2 (0.5)	20 (6)	60 000 (54 000)
24	19 (8)	0 (0)	0 (0)	19 (8)	12 (4)	570 000 (520 000)

TABLE 2. SELECTED SAND AND GRAVEL RESOURCE AREAS, NORTHWEST OF FORT FRANCES.

1 DEPOSIT NO.	2 AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE AGGREGATE Tons (Tonnes)
25	1.0 (0.4)	0 (0)	0 (0)	1.0 (0.4)	12 (4)	30 000 (27 000)
26	1.3 (0.5)	0 (0)	0 (0)	1.3 (0.5)	10 (3)	32 500 (29 500)
27	8 (3)	0 (0)	0 (0)	8 (3)	15 (5)	300 000 (270 000)
28	0.9 (0.4)	0 (0)	0 (0)	0.9 (0.4)	6 (2)	13 500 (12 200)
29	0.8 (0.3)	0 (0)	0 (0)	0.8 (0.3)	12 (4)	24 000 (21 800)
30	3.6 (1.5)	0 (0)	0 (0)	3.6 (1.5)	15 (5)	135 000 (122 000)
31	6 (2)	0 (0)	0 (0)	6 (2)	15 (5)	225 000 (204 000)
32	2.0 (0.8)	0 (0)	0 (0)	2.0 (0.8)	15 (5)	75 000 (68 000)
33	0.8 (0.3)	0 (0)	0 (0)	0.8 (0.3)	8 (2)	16 000 (14 500)
34	6 (2)	0 (0)	0 (0)	6 (2)	15 (5)	225 000 (204 000)
35	1.0 (0.4)	0 (0)	0 (0)	1.0 (0.4)	8 (2)	20 000 (18 100)
36	2.1 (0.8)	0 (0)	0 (0)	2.1 (0.8)	15 (5)	79 000 (72 000)
37	0.8 (0.3)	0 (0)	0 (0)	0.8 (0.3)	10 (3)	20 000 (18 100)
38	2.4 (1.0)	0 (0)	0 (0)	2.4 (1.0)	20 (6)	120 000 (109 000)
39	4.8 (1.9)	0 (0)	0 (0)	4.8 (1.9)	15 (5)	180 000 (163 000)
40	128 (52)	38 (15)	0 (0)	90 (36)	6 (2)	1 million (1 million)
41	12 (5)	0 (0)	0 (0)	12 (5)	25 (8)	750 000 (680 000)
42	6 (2)	0 (0)	0 (0)	6 (2)	35 (11)	520 000 (470 000)
43	12 (5)	0 (0)	0 (0)	12 (5)	15 (5)	450 000 (410 000)
44	840 (340)	39 (16)	1.0 (0.4)	800 (325)	15 (5)	30 million (27 million)
45	430 (174)	9 (4)	6 (2)	415 (168)	15 (5)	16 million (14 million)
46	40 (16)	5 (2)	5 (2)	30 (12)	15 (5)	1 million (1 million)
	1810 (730)	93 (38)	18 (7)	1700 (690)		64 million (58 million)

TABLE 3. RESULTS OF AGGREGATE QUALITY TESTS, NORTHWEST OF FORT FRANCES.

COARSE AGGREGATE			
Sample No.	Petrographic Number		Los Angeles Abrasion % Loss
	GBC & 16 mm Crushed	Hot Mix & Concrete	
Pit 2	102	125	24
Pit 5	101	113	19
Pit 10b	100	108	25
FF-SS-8	103	132	-

NOTE: The quality refers strictly to a specific sample taken at the time of field investigation. Because of the inherent variability of sand and gravel deposits, care should be exercised in extrapolating such information to the rest of the deposit.

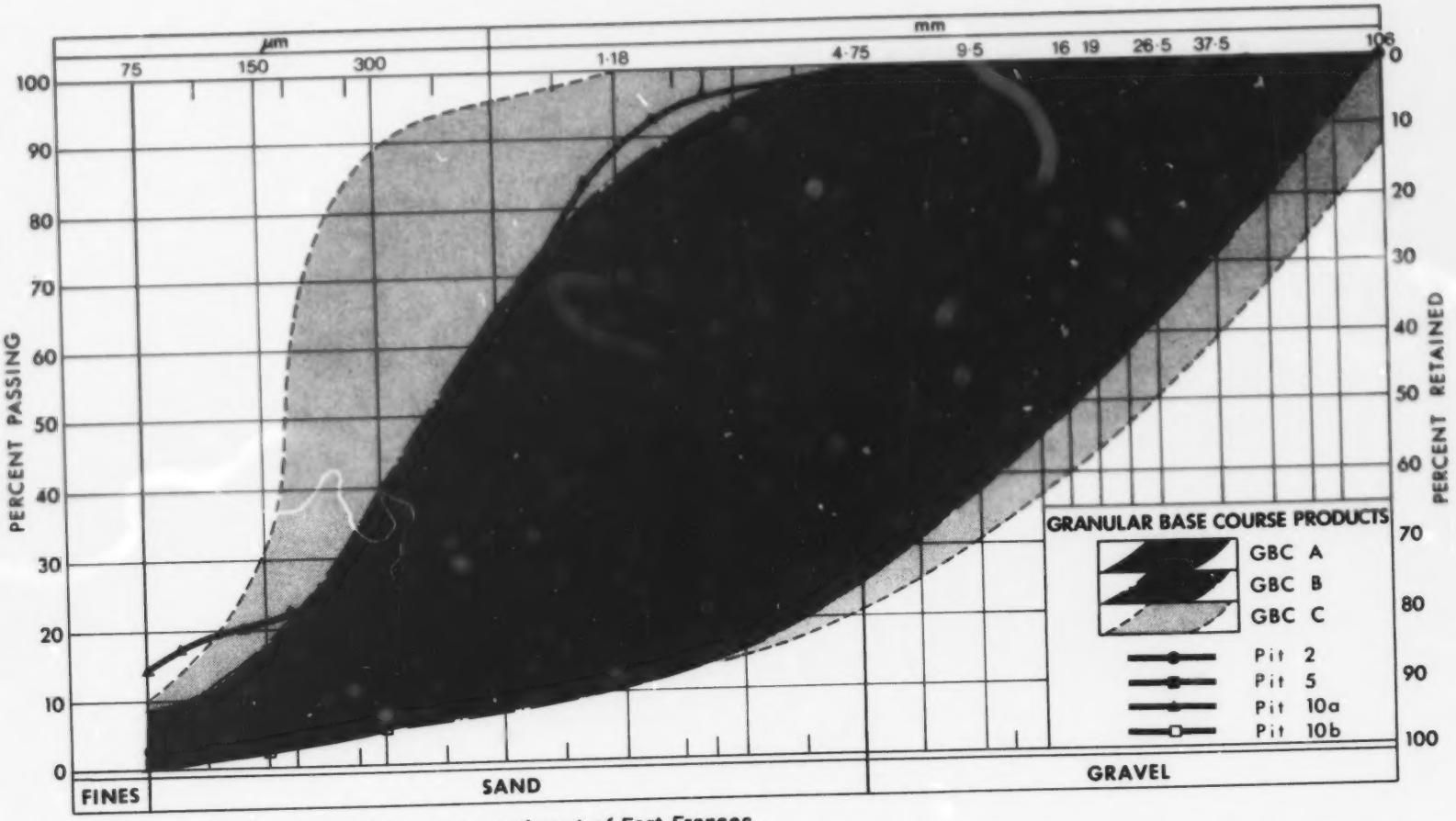


Figure 19a. ***Aggregate grading curves, northwest of Fort Frances.***

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

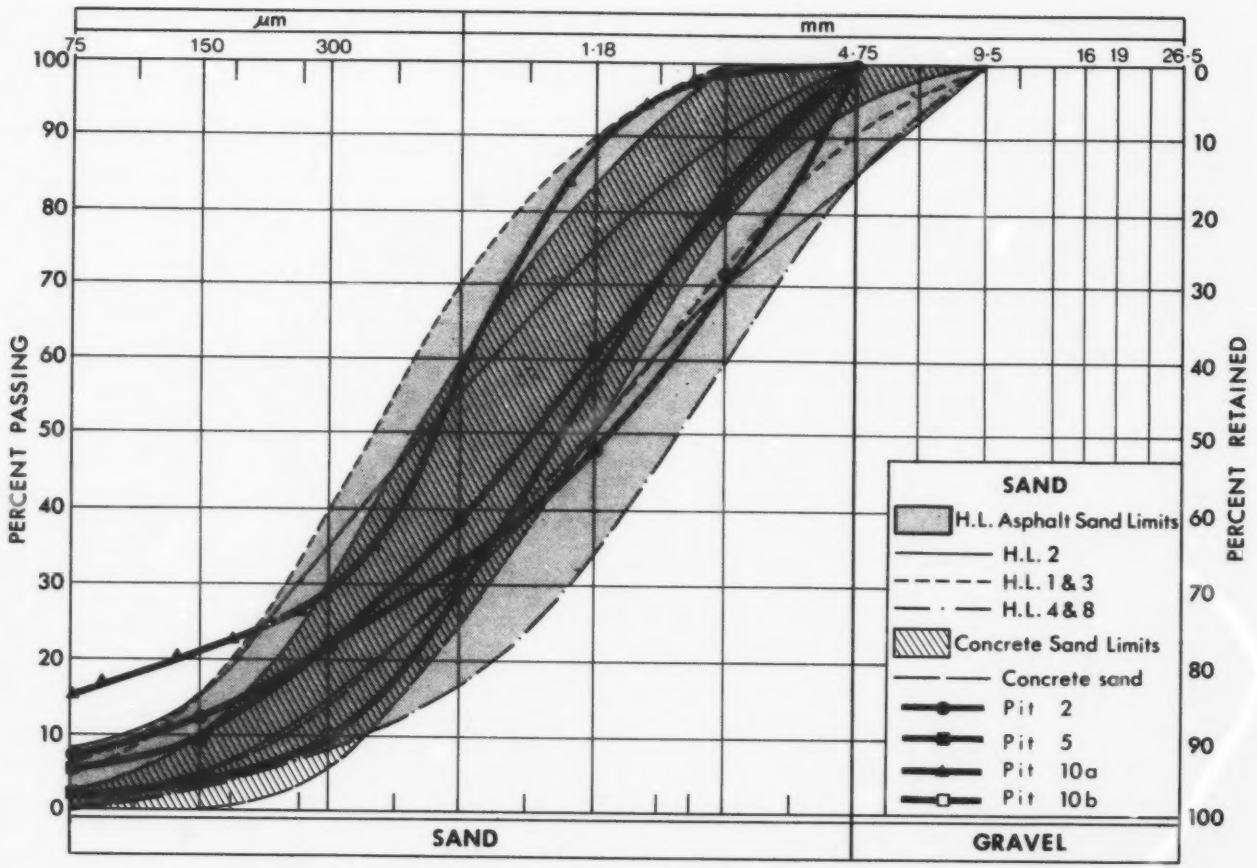


Figure 19b. ***Aggregate grading curves, northwest of Fort Frances.***

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

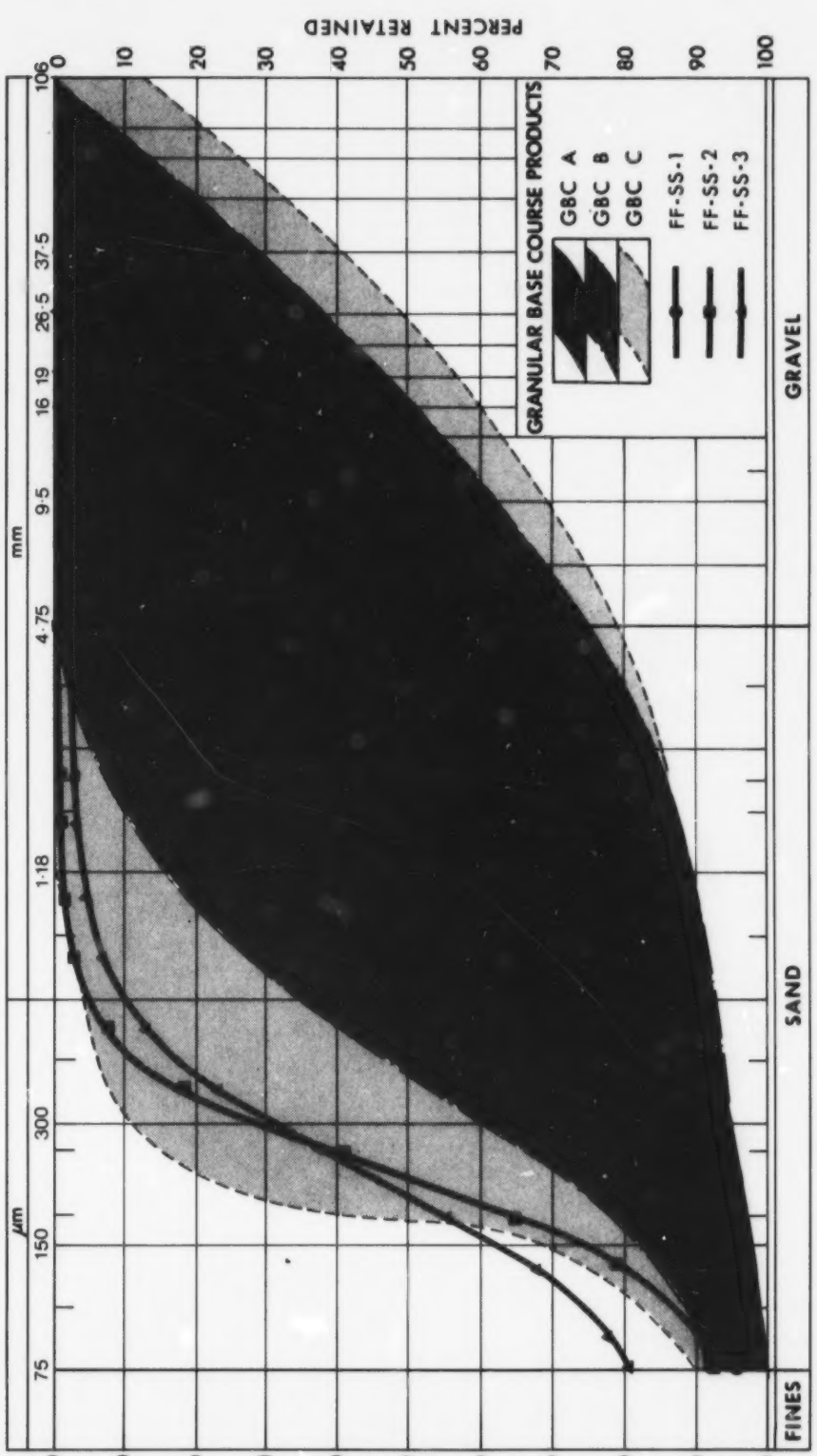


Figure 20a. ***Aggregate grading curves, northwest of Fort Frances.***

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

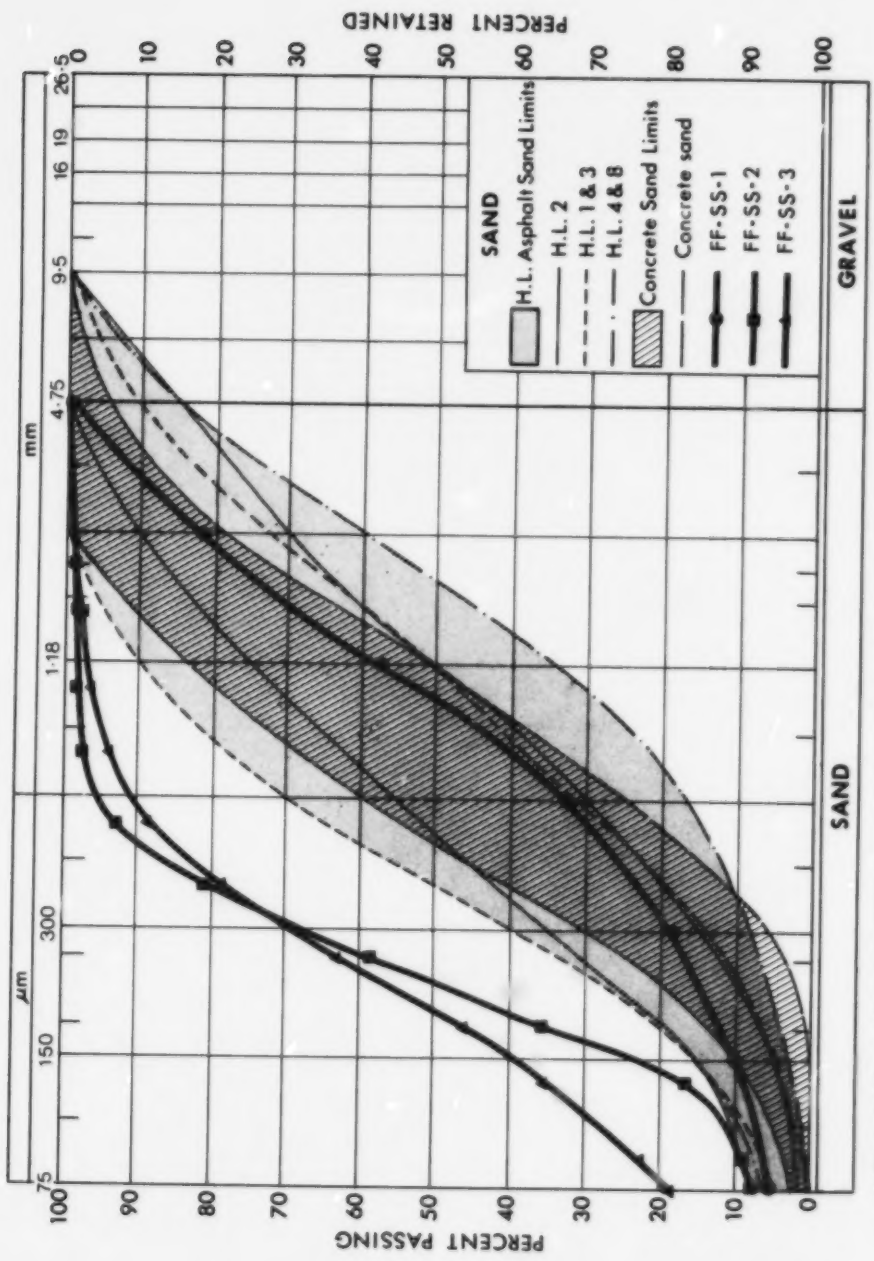


Figure 20b. *Aggregate grading curves, northwest of Fort Frances.*

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

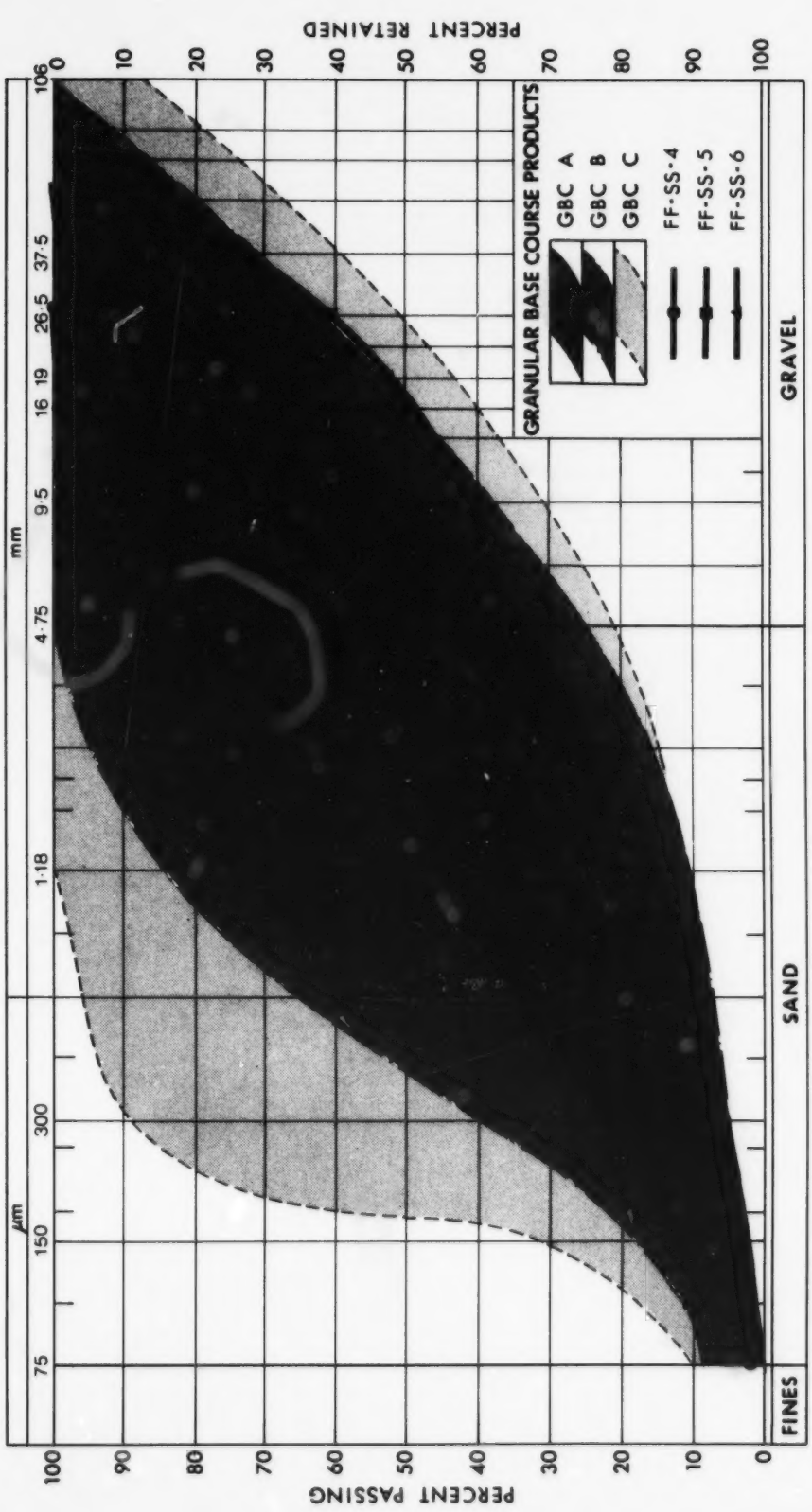


Figure 21a. ***Aggregate grading curves, northwest of Fort Frances.***

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

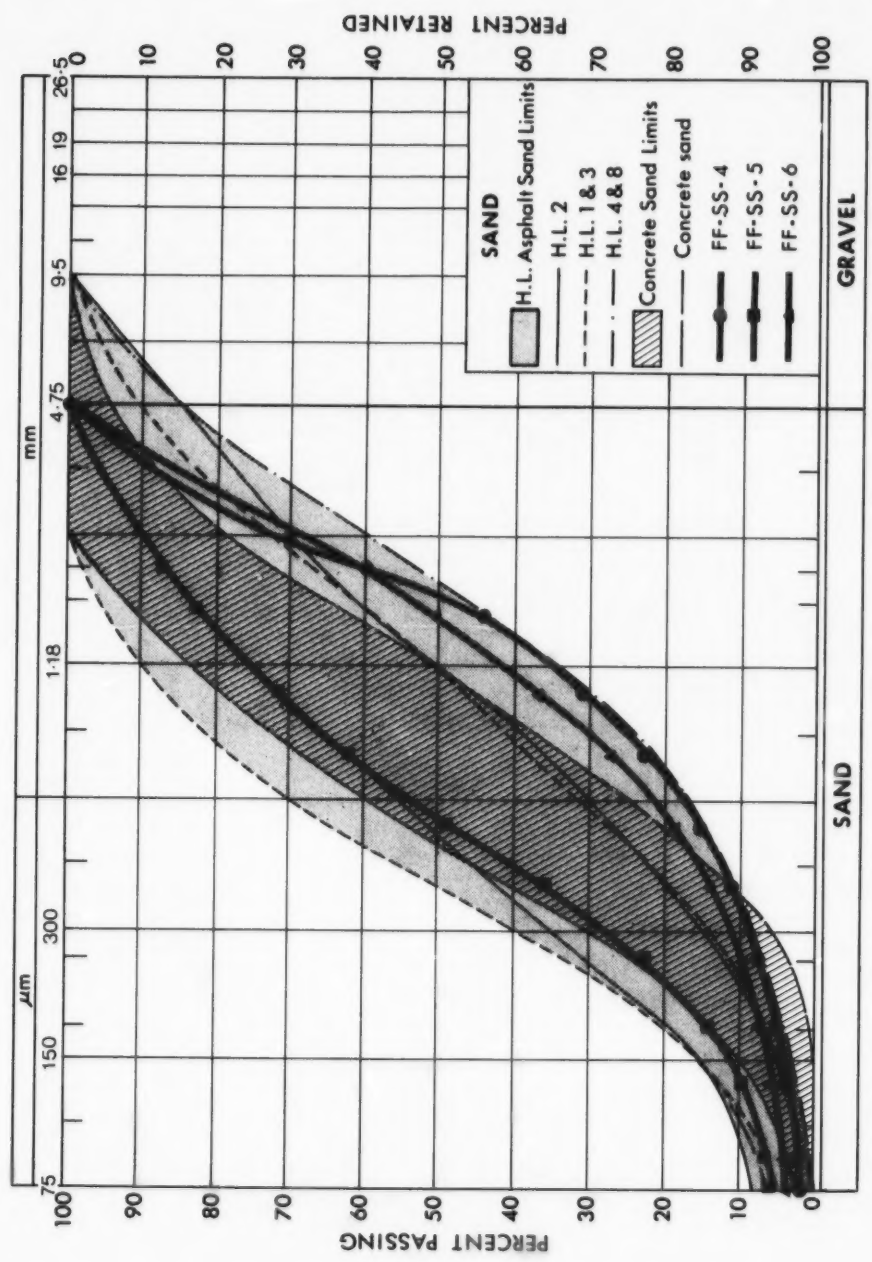


Figure 21b. ***Aggregate grading curves, northwest of Fort Frances.***

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

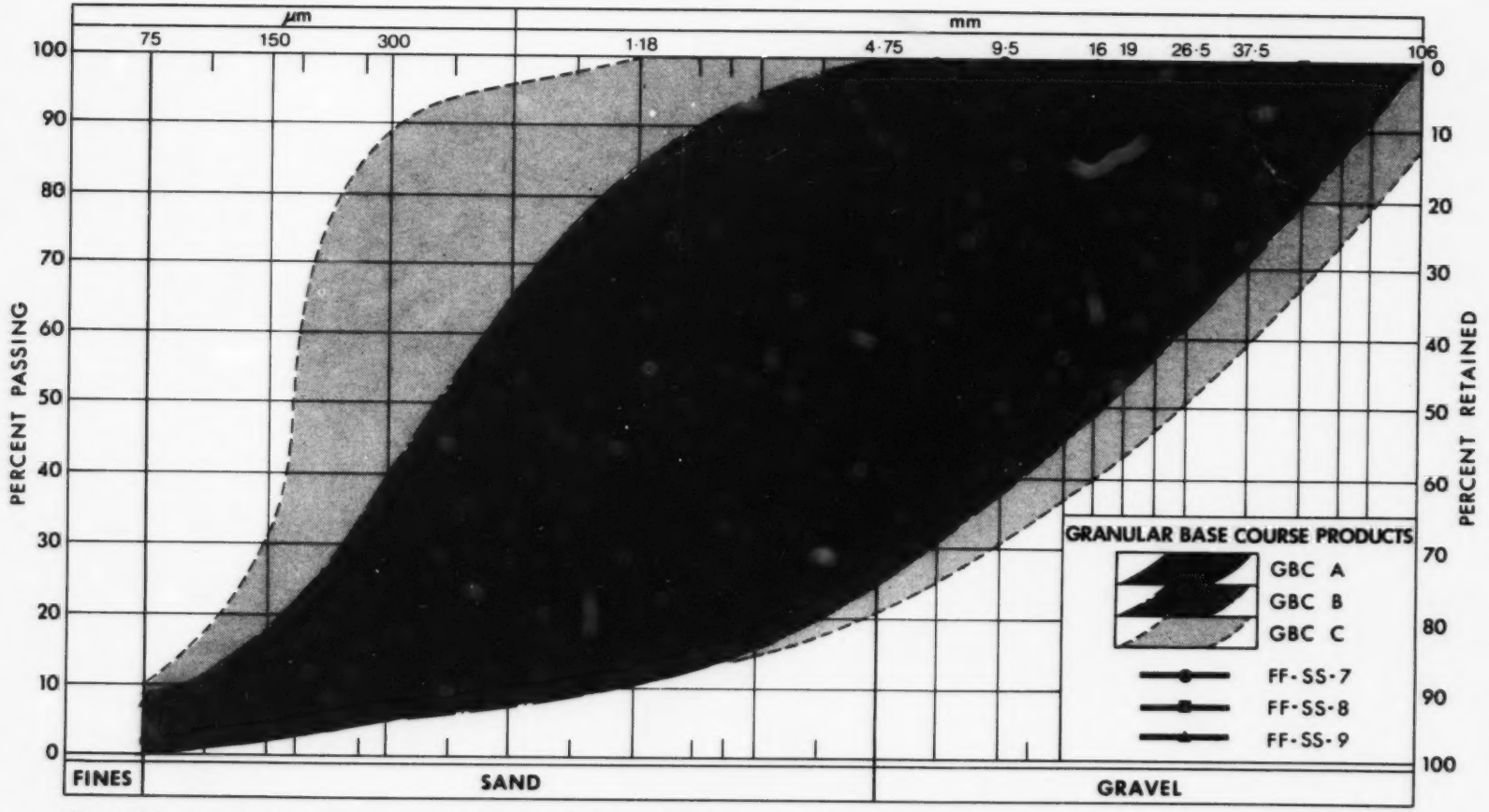


Figure 22a. ***Aggregate grading curves, northwest of Fort Frances.***

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

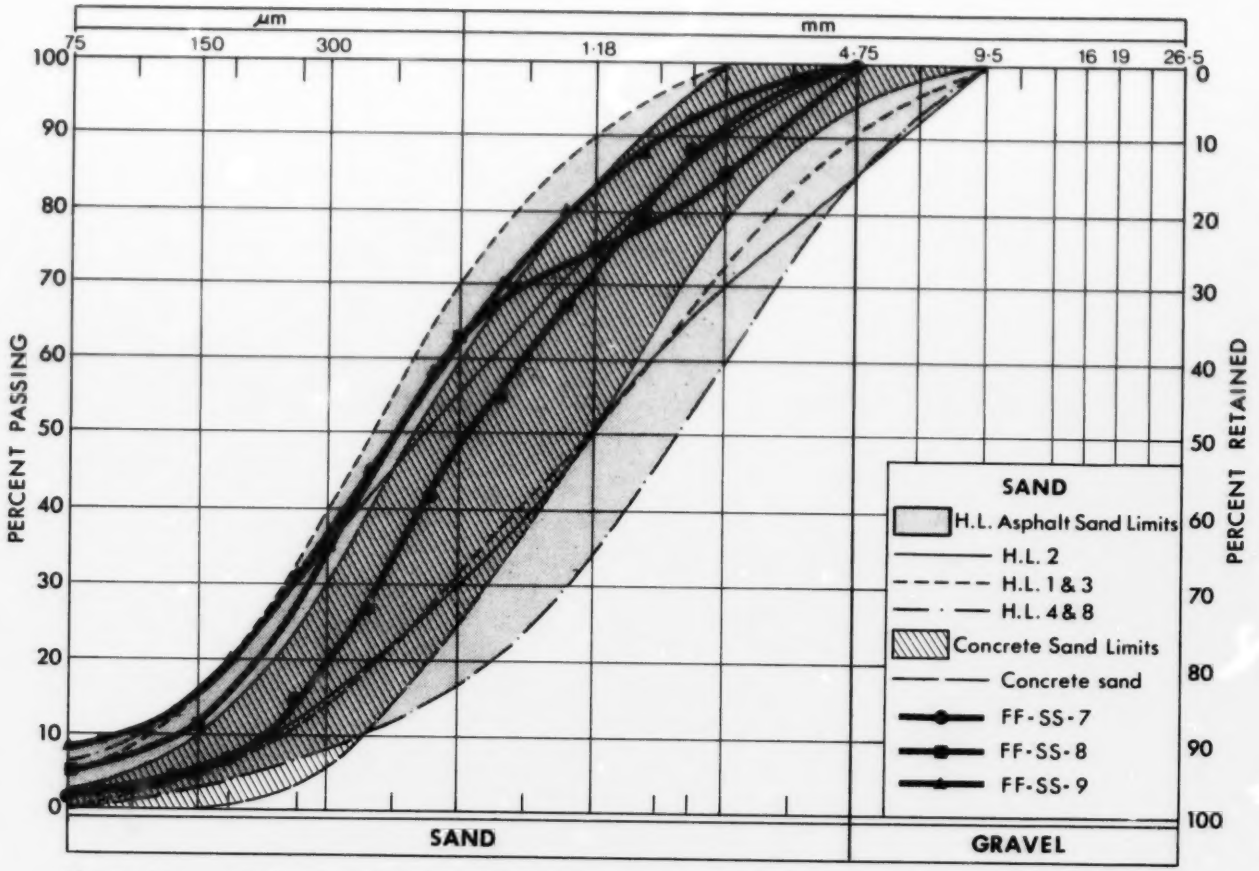


Figure 22b. ***Aggregate grading curves, northwest of Fort Frances.***

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

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Appendix B — Glossary

ABRASION RESISTANCE: Tests such as the Los Angeles abrasion test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

ABSORPTION CAPACITY: Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

AGGREGATE: Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

AGGREGATE ABRASION VALUE: This test directly measures the resistance of aggregate to abrasion with silica sand and a steel disk. The higher the value, the lower the resistance to abrasion. For high quality asphalt surface course uses, values of less than 6 are desirable.

ALKALI-AGGREGATE REACTION: A chemical reaction between the alkalis of portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for structural concrete uses.

BENEFICIATION: Beneficiation of aggregates is a process or combination of processes which improves the quality (physical properties) of a mineral aggregate and is not part of the normal processing for a particular use, such as routine crushing, screening, washing, or classification. Heavy media separation, jigging, or application of special crushers (e.g., "cage mill") are usually considered processes of beneficiation.

BLENDING: Required in cases of extreme coarseness, fineness, or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

BULK RELATIVE DENSITY: An aggregate with low relative density is lighter in weight than one with a high relative density. Low relative density aggregates (less than about 2.5) are often non-durable for many aggregate uses.

CAMBRIAN: The first period of the Paleozoic Era, thought to have covered the time between 570 and 500 million years ago. The Cambrian precedes the Ordovician Period.

CLAST: An individual constituent, grain or fragment of a sediment or rock, produced by the mechanical weathering of larger rock mass. Synonyms include particle and fragment.

CRUSHABLE AGGREGATE: Unprocessed gravel containing a minimum of 35 percent coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20 percent greater than the 26.5 mm sieve.

DELETERIOUS LITHOLOGY: A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

DRIFT: A general term for all unconsolidated rock debris transported from one place and deposited in another, distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DRUMLIN: A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were formed beneath an advancing ice sheet, and were shaped by its flow.

EOLIAN: Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

FINES: A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

GLACIAL LOBE: A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced then melted back numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in Ontario.

GNEISS: A coarse-textured metamorphic rock with the minerals arranged in parallel streaks or bands. Gneiss is relatively rich in feldspar. Other common minerals found in this rock include quartz, mica, amphibole and garnet.

GRADATION: The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durabil-

ity, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

GRANITE: A coarse-grained, light-coloured rock that ordinarily has an even texture and is composed of quartz, and feldspar with either mica, hornblende or both.

GRANULAR BASE COURSE: Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

HOT-LAID (OR ASPHALTIC) AGGREGATE: Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (HL 1, 3 and 4), or as binder course (HL 2 and 8) used to bind the surface course to the underlying granular base course.

LITHOLOGY: The description of rocks on the basis of such characteristics as colour, structure, mineralogic composition and grain size. Generally, the description of the physical character of a rock.

LOS ANGELES ABRASION AND IMPACT TEST: This test measures the resistance to abrasion and the impact strength of aggregate. This gives an idea of the breakdown that can be expected to occur when an aggregate is stockpiled, transported, and placed. Values less than about 35 percent indicate potentially satisfactory performance for most concrete and asphalt uses. Values of more than 45 percent indicate that the aggregate may be susceptible to excessive breakdown during handling and placing.

MAGNESIUM SULPHATE SOUNDNESS TEST: This test is designed to simulate the action of freezing and thawing on aggregates. Those aggregates which are susceptible will usually break down and give high losses in this test. Values greater than about 12 to 15 percent indicate potential problems for concrete and asphalt coarse aggregate.

MELTWATER CHANNEL: A drainage way, often terraced, produced by water flowing away from a melting glacier margin.

PETROGRAPHIC EXAMINATION: An aggregate quality test based on known field performance of various rock types. In Ontario the test result is a Petrographic Number (PN). The higher the PN the lower the quality of the aggregate.

PLEISTOCENE: An epoch of the recent geological past incuding the time from approximately 2 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

POLISHED STONE VALUE: This test measures the frictional properties of aggregates after 6 hours of abrasion and polishing with an emery abrasive. The higher the PSV, the higher the frictional properties of the aggregate. Values less than 45 indicate marginal frictional properties, while values greater than 55 indicate excellent frictional properties.

POSSIBLE RESOURCE: Reserve estimates based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

PRECAMBRIAN: The earliest geological period extending from the consolidation of the earth's crust to the beginning of the Cambrian.

SOUNDNESS: The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

TILL: Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN: Pertaining to the last glacial period of the Pleistocene Epoch in North America. The Wisconsinan began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of southern Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

Appendix C — Geology of Sand and Gravel Deposits

The type, distribution, and extent of sand and gravel deposits in Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

Ice-Contact Terraces (ICT) These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous because of extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive because of the variability of the deposits both in terms of quality and grain size distribution.

Lee Side Ice-Contact Deposit (ICL) A general term for ice-contact stratified drift deposited on the lee side of bedrock ridges. Lee side ice-contact features are typically small features and are common throughout the Precambrian shield areas in Ontario.

Kames (K) Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits, producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and cross-bedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt- and clay-sized particles).

Eskers (E) Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers, consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

Undifferentiated Ice-Contact Stratified Drift (IC) This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits because of their lack of continuity and grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

Outwash (OW) Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

Subaqueous Fan (SF) Subaqueous fans are formed within or near the mouths of meltwater conduits when sediment-laden meltwaters are discharged into a standing body of water. The geometry of the resulting deposit is fan- or lobe-shaped. Several of these lobes may be joined together to form a larger, continuous sedimentary body. Internally, subaqueous fans consist of stratified sands and gravels which may exhibit wide variations in grain size distribution. As these features were deposited under glacial lake waters, silt and clay which settled out of these lakes may be associated in varying amounts with these deposits. The variability of the sediments and

presence of fines are the main extractive problems associated with these deposits.

Alluvium (AL) Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and they have generally low value because of the presence of excess silt- and clay-sized material. There are few large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

Glaciolacustrine Beach Deposits (LB) These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the source material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

Glaciolacustrine Deltas (LD) These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

Glaciolacustrine Plains (LP) The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources because of their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

End Moraines (EM) These are belts of glacial drift deposited at, and parallel to, glacier margins. End moraines commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

Windblown Deposits (WD) Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments almost always consist of fine to coarse sand and are usually well sorted. The probabiltiy of locating crushable aggregate in windblown deposits is very low.

Appendix D — Aggregate Quality Testing

Four types of aggregate quality tests have been performed on selected samples from the project area. A description and the specification limits for each test are included in this appendix. Although a specific sample meets or does not meet the specification limits for a certain product, it may or may not be acceptable for that use based on field performance. Additional quality tests other than the four major tests listed in this appendix can be used to determine the suitability of an aggregate. The above four types of tests were performed by the Soils and Aggregates Section, Engineering Materials Office, Ontario Ministry of Transportation.

Absorption Capacity Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate. This test is conducted in conjunction with the determination of the sample's relative density.

Los Angeles Abrasion and Impact Test This test measures the resistance to abrasion and the impact strength of aggregate. This gives an idea of the breakdown that can be expected to occur when an aggregate is stockpiled, transported, and placed. Values less than about 35 percent indicate potentially satisfactory performance for most concrete and asphalt uses. Values of more than 45 percent indicate that the aggregate may be susceptible to excessive breakdown during handling and placing.

Magnesium Sulphate Soundness Test This test is designed to simulate the action of freezing and thawing on aggregate. Those aggregates which are susceptible will usually break down and give high losses in this test. Values greater than about 12 to 15 percent indicate potential problems for concrete and asphalt coarse aggregate.

Petrographic Examination Individual aggregate particles in a sample are divided into categories good, fair, poor, and deleterious, based on their rock type (petrography) and knowledge of past field performance. A petrographic number (PN) is calculated. The higher the PN, the lower the quality of the aggregate.

TABLE D1. SELECTED QUALITY REQUIREMENTS FOR MAJOR AGGREGATE PRODUCTS

	TYPE OF TEST				
	COARSE AGGREGATE				FINE AGGREGATE
TYPE OF MATERIAL	Petrographic Number Maximum	Magnesium Sulphate Soundness Maximum % Loss	Absorption Maximum %	Los Angeles Abrasion Maximum % Loss	Magnesium Sulphate Soundness Maximum % Loss
Granular Base A	200	–	–	60	–
16 mm Crushed Type 'A'	160	–	–	35	–
16 mm Crushed Type 'B'	200	–	–	60	–
Granular Subbase B	250	–	–	–	–
Granular Subbase C	250	–	–	–	–
Granular Subbase D	–	–	–	–	–
Hot Mix – HL 1	100	5	1.0	15	16
Hot Mix – HL 2	–	–	–	–	–
Hot Mix – HL 3	135	12	1.75	35	16
Hot Mix – HL 4	160	12	2.0	35	20
Hot Mix – HL 8	160	15	2.0	35	20
Structural Concrete and Concrete Base	140	12	2.0	35	16
Pavement Concrete and Exposed Structure Deck	125	12	2.0	35	16

(Ministry of Transportation Forms 1002, 1003 and 1010)

MAPS
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